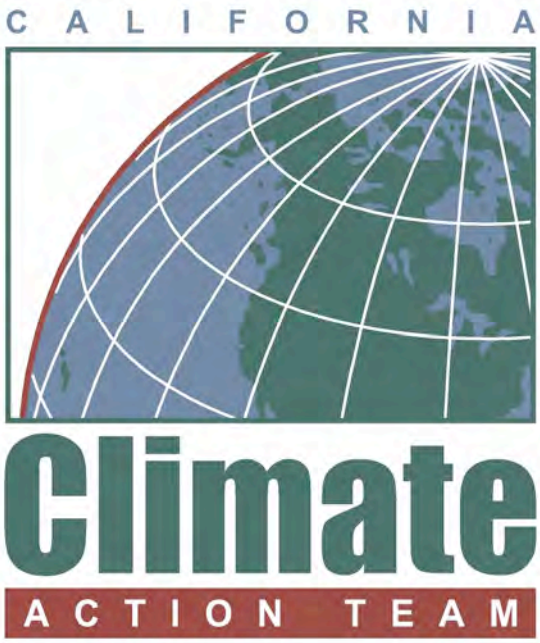
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Climate Action Team Report to the Governor and Legislature



December 8, 2005

EXECUTIVE SUMMARY

Climate change is widely recognized by scientists throughout the world to be one of the most daunting challenges of our time. Adoption of precautionary and proactive measures are imperative if climate change emissions are to be reduced and stabilized and communities are to successfully adapt to the coming impacts of climate change.

California is the twelfth largest source of climate change emissions in the world, exceeding most entire countries. Actions taken in this state make a difference; not only because we are a major contributor to the problem but also because California is known throughout the world as a leader in addressing public health and environmental issues.

On June 1, 2005, Governor Schwarzenegger committed California to be a leader in addressing climate change by declaring, “I say the debate is over. We know the science. We see the threat. And we know the time for action is now.” The Governor signed Executive Order S-3-05 which called for: a reduction of greenhouse gas emissions to 2000 levels by 2010; a reduction in greenhouse gas emissions to 1990 by 2020; and a reduction in greenhouse gas emissions to 80 percent below 1990 levels by 2050.

There are a number of California companies whose voluntary actions support the Governor’s targets. More than 50 companies have joined the voluntary California Climate Action Registry and are reporting their emissions and discovering best practices to reduce these emissions. In the Silicon Valley, dozens of corporations have committed to reducing their emissions to 20 percent below 1990 levels by 2010.

The Climate Group, an independent, nonprofit organization dedicated to advancing business and government leadership on climate change, keeps a running tab on Fortune 500 companies such as DuPont, Honda, Johnson and Johnson, and Kodak. The Climate Group reports on emissions reduced and dollars saved by these companies due to their voluntary actions. Technologies that reduce climate change emissions are increasingly in demand in the world marketplace, and California companies investing in those technologies are well placed to benefit from this demand.

This report provides direction for the next two years that will result in reduced climate change emissions and will better position the state for adapting to the adverse consequences of climate change. The report also describes specific strategies that can be implemented by California’s State agencies to reduce the state’s carbon footprint.

The report identifies four recommendations that require action by the Governor and the Legislature. They are, as a package, intended to encourage investment in technologies that reduce emissions, create jobs, and encourage economic

growth. These recommendations listed below are considered essential to meeting the Governor's targets:

Mandatory Climate Change Emissions Reporting that builds upon California's Climate Action Registry and allows this state to track progress towards meeting the Governor's targets. Collecting emissions data, starting with data from the largest sources of emissions, will allow the Governor's targets to be translated into a statewide emission cap for the 2010 and 2020 timeframes (and lay the foundation for a cap and trade program).

A Public Goods Charge for Transportation that funds key strategies to reduce climate change emissions and to reduce dependence on petroleum. Overdependence on petroleum fosters undesirable geopolitical, economic, energy, and environmental consequences.

A Coordinated Investment Strategy for the State Funding Programs—such as the State Pension System, Public Interest Energy Research fund, and other state investment programs—that works to achieve the many benefits of transitioning to a low carbon footprint. The investment strategy would provide incentives for industry to develop emission reduction technologies for use in California and abroad, thereby maintaining California's lead in technology development. It should also leverage the talent at California's universities to develop new technologies for reducing emissions and train the next generation of technicians that will be necessary to operate and service these technologies.

Provisions for Early Action Credit to California businesses that supports the transition to federal and international emission reduction schemes, including a cap and trade program. Such a provision would ensure that companies proactive in advance of such schemes are not penalized.

CLIMATE CHANGE OVERVIEW

Human activities are altering the chemical composition of the atmosphere through the rapid buildup of climate change emissions—primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons. Atmospheric concentrations of these gases in the ambient atmosphere are increasing at a rate not experienced for millions of years, according to ice core samples and other records. Although there is some uncertainty about exactly how and when the earth's climate will respond to increasing concentrations of climate change emissions, observations in conjunction with climate models indicate that detectable changes are underway.

These observed changes go beyond a global mean rise in temperature and include changes in regional temperature extremes, precipitation, soil moisture, and sea level. All of these changes could have significant adverse effects on water resources and ecological systems, as well as on human health and the

economy. The diversity and complexity of the state's vulnerability to rising climate change emissions should both humble and profoundly motivate the state's policy leaders. As Lord John Browne, Group Chief Executive of British Petroleum, once observed—it must be addressed in a manner analogous to nuclear proliferation—with constant "momentum".[1]

There is no scientific uncertainty about the fact that human activities have increased the atmospheric abundance of climate change emissions. The uncertainties start when we try to predict exactly what climate changes will be in various local areas of the Earth, and what the effects of clouds will be in determining the rate at which the mean temperature will increase.

There are also uncertainties associated with the magnitude and timing of other consequences of a warmer planet: sea level rise, spread of certain diseases out of their usual geographic range, the effect on agricultural production, water supply, sustainability of ecosystems, increased strength and frequency of storms, extreme heat events, air pollution episodes, and the consequence of these effects on the economy. Already, some of these effects have been seen in California. Over the last hundred years, average temperatures have increased 1.2^{o}F, sea levels have risen by 3 to 8 inches, and spring runoff has decreased 12 percent.

EXECUTIVE ORDER S-3-05

In recognition of the risks associated with climate change and the imperative for California to take action, Governor Schwarzenegger signed Executive Order S-3-

[1] Lord John Browne, CEO, BP, Florence, Italy, November 10, 2000: "To me, the process of reducing the risks of climate change is comparable to the process of disarmament: there is a constant need to maintain momentum."

05 (EO). This EO established statewide climate change emission reduction targets shown in Table ES-1.

Table ES-1 California's Climate Change Emission Reduction Targets

By 2010, Reduce Emissions to 2000 Levels*

By 2020, Reduce Emissions to 1990 Levels**

By 2050, Reduce Emissions to 80% Below 1990 Levels

* 59 Million Tons Reduction, 11% below Business as Usual

** 145 Million Tons Reduction, 25% Below Business as Usual

To meet these targets California will build upon leadership actions already taken by this state and supported by Governor Schwarzenegger and the Legislature.

The EO also directed the Secretary for Environmental Protection (Secretary) to prepare a report to the Governor and the Legislature by January 2006 that defines actions necessary to meet the Governor's targets. This effort is to be coordinated with other key agencies to ensure the targets are met. Progress towards meeting the targets must be provided in subsequent reports every two years. These reports must also include scientific analysis of climate change impacts on the state and adaptation measures that can be taken by the state in response to the adverse consequences of these impacts.

Consistent with the EO direction, a Climate Action Team (CAT) was formed. The CAT is comprised of knowledgeable representatives from the following: Air Resources Board; Business, Transportation and Housing Agency; Department of Food and Agriculture; Energy Commission; Integrated Waste Management Board; Public Utilities Commission; and Resources Agency. This team has developed a list of emission reduction strategies that are necessary to meet the Governor's targets. Further, the CAT reviewed the work by some of California's top scientists regarding the impacts of climate change on California and potential adaptation measures to combat adverse impacts.

STRATEGIES UNDERWAY TO REDUCE CLIMATE CHANGE EMISSIONS

California agencies have already undertaken a number of strategies to reduce emissions as shown in Table ES-2. The landmark climate change emission reduction motor vehicle regulations were adopted by the Air Resources Board in

September 2004 and will require cleaner cars to be sold in California beginning in 2009. The Governor has supported the California Energy Commission and Public Utilities Commission in their efforts to accelerate the Renewable Portfolio Standard so that 20 percent of the power from regulated utilities will come from renewable resources by 2010 increasing to 33 percent by 2020.

For three decades the California Energy Commission has led the world with the most progressive new building and appliance efficiency standards. These efficiency standards have provided substantial climate change emission reductions and have saved consumers about $1,000 per household in California. Finally, current efforts to reduce waste and increase recycling as well as our ambitious Green Buildings and Hydrogen Highway initiatives are other activities that will contribute to meeting the emission reduction targets.

Many of the strategies listed in Table ES-2 also reduce ozone and criteria and toxic pollutants. (Criteria pollutants are a type of pollutant: oxides of nitrogen, carbon monoxide, and hydrocarbons). Although the degree to which they contribute to climate change has not been fully quantified, ozone, most criteria pollutants and particulate matter emissions are being evaluated for their climate forcing potential. Further iterations of this report will update the Governor and Legislature on the results. For now, the actions listed in Table ES-2 and all other actions that reduce criteria pollutants and ozone contribute to meeting the Governor's targets.

TABLE ES-2 Strategies Underway in California Agency Responsible Strategies	Climate Change Emission Reductions[1] (Million Tons CO_2 Equivalent)	
	2010	2020
Air Resources Board		
Vehicle Climate Change Standards	1	30
Diesel Anti-idling	1	1.2
Public Utilities Commission		
Accelerated Renewable Portfolio Std to 33% by 2020 (includes load-serving entities [LSE])	5	11
California Solar Initiative	0.4	3
Investor-Owned Utility Energy Efficiency Programs (includes LSEs)	4	8.8

Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Energy Commission		
Building Energy Efficiency Standards	1	2
Appliance Energy Efficiency Standards	3	5
Fuel-efficient Replacement Tires & Inflation Programs	1.5	1.5
State and Consumer Services/CalEPA		
Green Buildings Initiative	0.5	1.8
Air Resources Board/CalEPA		
Hydrogen Highway	Not yet estimated	
Total Potential Emission Reductions	22	67

[1]These Estimates are based on best available current data and are subject to change

EMISSION REDUCTION STRATEGIES NEEDED TO MEET THE GOVERNOR'S TARGETS

The Climate Action Team also developed a list of additional strategies necessary to achieve the Governor's emission reduction targets. A list of these strategies is shown in Table ES-3. Some of these strategies are partially underway and their responsible agencies have existing authority to affect their implementation. Others will require legislative action; the responsible agencies are developing the necessary legislative actions for review by the Governor and Legislature.

The strategies in Table ES-3 span a variety of emission sources. Upon their implementation these strategies will ensure the Governor's targets are met.

Table ES-3 Strategies Necessary to Meet California's Targets

Agency Responsible	Start Date	Climate Change Emission Reductions (Million Tons CO_2 Equivalent)[1] 2010 2020

Air Resources Board			
Other New Light Duty Vehicle Technology Improvements	2006	0	6
HFC Reduction Strategies	2006	3.4	8.5
Transport Refrigeration Units, Off-Road Electrification, Port Electrification (ship to shore)	2006	<1	<1
Manure Management	2006	0	1
Semi Conductor Industry Targets (PFC Emissions)	2006	2	2
Alternative Fuels: Biodiesel Blends	2006	<1	<1
Alternative Fuels: Ethanol	2006	<1	2.7
Heavy Duty Vehicle Emission Reduction Measures	2006	0	3
Reduced Venting and Leaks in Oil and Gas Systems	2006	1	1
Public Utilities Commission			
IOU Additional Energy Efficiency Programs/Demand Response	2013	NA	6.3
IOU Combined Heat and Power Initiative	2006	1.1	4.4
IOU Electricity Sector Carbon Policy	2006	1.6	2.7
Integrated Waste Management Board			
Landfill Methane Capture	2006	2	3
Zero Waste—High Recycling	2006	0	3
Resources Agency			
Forest Management	2006	1-2	2-4
Forest Conservation	2006	4.2	8.4
Fuels Management/Biomass	2006	3.4	6.8
Urban Forestry	2006	0	3.5
Afforestation (planting trees)/Reforestation	2006	0	12.5
Water Use Efficiency	2008	<1	1.2
Energy Commission			
Building Energy Efficiency Standards	2005	TBD	TBD
Appliance Energy Efficiency Standards	2006	TBD	TBD

Cement Manufacturing	2006	<1	<1
Municipal Utility Energy Efficiency Programs/ Demand Response	2006	1	5.9
Municipal Utility Renewable Portfolio Standard	2006	<1	3.2
Municipal Utility Combined Heat and Power	2006	0	<1
Municipal Utility Electricity Sector Carbon Policy	2006	3	9
Alternative Fuels: Non-Petroleum Fuels	2006	TBD	TBD
State and Consumer Services/CalEPA			
Transportation Policy Implementation	Still Being Considered		
Business, Transportation & Housing			
Measures to Improve Transportation Energy Efficiency	2006	1.8	9
Smart Land Use and Intelligent Transportation	2006	5.5	18
Department of Food & Agriculture			
Conservation tillage/cover crops	2006	TBD	TBD
Enteric Fermentation	2006	<1	<1
Total Potential Emission Reductions	[1]	35-40	115-120

[1]These Estimates are based on best available current data and are subject to change

SCENARIO ANALYSIS

The scientific analysis underway to determine the impacts of climate change on California and potential adaptation measures is referred to here as the Scenario Analysis. Three scenarios were selected to determine the range of possible impacts from climate change. These scenarios come directly from the Intergovernmental Panel on Climate Change (IPCC) 2001 report and represent high, medium, and low-emission scenarios. (High = A1fi scenario in the IPCC report; medium = A2 scenario; low = B1 scenario.)

This analysis considers impacts on water resources, public health, agriculture, coastline, forests, and electricity demand based on the three emission scenarios. The analysis in this report stems directly from the ongoing work being done by the Energy Commission. It represents a mid-point check in the current five-year plan the Energy Commission has underway to evaluate climate change impacts in the state.

Based on the analysis completed to date, the following consequences of climate change on California will be severe and will be experienced on both an acute and chronic basis:

A diminishing Sierra snowpack of up to 90 percent during the next 100 years threatens California's water supply and quality as the Sierra accounts for almost all of the surface water storage in the state.

Increasing temperatures from 8 to 10.4 ºF, as expected under the higher emission scenarios, will cause a 25 to 35 percent increase in the number of days Californians are exposed to ozone pollution in most urban areas. This will offset many of the state's efforts to reduce pollution. Temperature increases are likely to mean an increase in heat-related deaths and pestilence. Those most vulnerable are at greater risk: children, the elderly, and minority and low-income communities.

The agriculture industry is one of the largest industries in the state. Potential impacts from limited water storage, increasing temperatures, and salt water in the levees would threaten this industry and its economic contribution to the state. Direct threats to the structural integrity of the state's levee system would also have immense implications for the state's fresh water supply, food supply, and overall economic prosperity.

Erosion of our coastlines and sea water intrusion into the state's delta and levee systems may result from a 4- to 33-inch rise in sea level during the next 100 years. This will further exacerbate flooding in vulnerable regions.

Pest infestation and increasing temperatures would make the state's forest resources more vulnerable to fires. Forest fires not only adversely affect the state's economy, they also cause increases in pollution damaging public health, visibility, and property.

Increasing temperatures will boost electricity demand, especially in the hot summer season. By 2020 this would translate to a 1 to 3 percent increase in demand resulting in potentially hundreds of millions of extra energy expenditures.

These impacts will affect everyone. However, in many cases the most vulnerable are children, the elderly, and the frail who suffer disproportionately when pollution increases and temperatures rise. Low-income and minority communities are also at greater risk as limited resources and current disparities in health care limit the capacity of residents in these communities to adapt and respond.

The scenario analysis also included an evaluation of adaptation measures that could be taken to respond to the adverse consequences of climate change. This evaluation is not complete, but at this point the adaptation measures identified include the following:

Study and use modern probabilistic weather and hydrological forecasts for the management of water reservoirs and other resources in the state.

Develop and implement heat emergency action plans with special emphasis in providing assistance to the elderly and those living in housing without air conditioning units.

Adopt short-term actions to improve our ability to live within California's fire-prone landscapes, while maintaining the functioning and structure of ecosystems upon which we depend.

Mitigate the impact of high temperatures on electricity demand with energy efficiency programs, increased penetration of photovoltaic systems and other forms of renewable energy, and the implementation of measures designed to reduce the urban heat island effect.

CAP AND TRADE OPTIONS FOR CALIFORNIA

"Cap and trade" is a market-based program that can be integral to California's strategy for reducing climate change emissions. The program sets an emissions cap that can be ratcheted down over time. The ability to trade emissions among sources enables emission reductions to be achieved at the least possible cost.

To maximize its effectiveness, a cap and trade program in California should encompass as many sources as possible and should certainly reach beyond just the electricity sector. However, the breadth of coverage must be tempered by administrative realities and source-specific considerations. Two alternatives for defining the scope of California's cap and trade program are a sector-based emissions cap and a fuels-based carbon cap.

A sector-based emissions cap would cover up to 30 percent of the state's climate change emissions by focusing on five key industries: electric power (including emissions from imported electricity); oil refining; oil and gas extraction; landfills; and cement production. Mobile sources, the largest source of climate change emissions in the state, are not recommended for inclusion under a sector-based emissions cap at this time.

As an alternative to a sector-based cap, climate change emissions can be reduced by capping the total carbon content of oil, gas, and coal consumed in the state. This approach encompasses all sectors that use fossil fuels, including those indicated in the paragraph above, covering 75 percent of the state's climate change emissions. All options for reducing fossil fuel combustion across all sectors can contribute to achieving the carbon cap. Additionally, all sectors are put on an equal footing as it relates to their use of fossil fuels.

A hybrid approach can be considered, for example, in which emissions from the electric power industry (including imported power) is capped and the carbon content of fuels is capped.

Emission offsets can be used to motivate emission reductions from sources outside the cap. Emission offsets help lower the cost of reducing emissions: facilities covered by the cap can purchase low-cost emission reductions from outside the cap as a means of complying with their emission limit. To ensure that offsets do not compromise the emission reduction goal of the program, they must be real, verifiable, quantifiable, in excess to any regulatory requirement, and not counted toward any other climate change emission reduction targets.

The primary weakness associated with implementing a cap and trade program in California is that it will be vulnerable to emission "leakage." If the state implements the program without other states, there will be an incentive for production to shift to neighboring states to avoid the cap. If this occurs, emissions may decline in the state, only to increase in neighboring states.

A coordinated national approach to capping climate change emissions within an international framework would be the best approach for addressing this leakage problem. In the absence of national action, or even regional action, the leakage issues may be partially addressed through the design of the program. As part of the implementation of a cap and trade program, data should be collected over time to assess the extent to which leakage occurs as well as its impacts on businesses and on the effectiveness of the emissions cap.

ECONOMIC IMPACTS

Preliminary economic analyses are underway for inclusion in the report to the Governor and Legislature.

IMPACTS ON LOW INCOME AND MINORITY COMMUNITIES

CalEPA has made the achievement of environmental justice (EJ) an integral part of its activities. Cal/EPA adopted its intra-agency EJ Strategy in August 2004 and its EJ Action Plan in October 2004. These policies establish a framework for incorporating environmental justice into the CalEPA's programs consistent with the directives of State law.

As the Climate Action Team developed this report to the Governor and the Legislature, agency staff worked with community leaders involved with environmental justice as well as with environmental and public health organizations to maintain an ongoing dialogue and thus successfully implement CalEPA's environmental justice policies.

The Climate Action Team has undertaken an evaluation to investigate if low-income and minority communities (communities) may be impacted disproportionately by climate change, efforts to adapt to climate change, and/or efforts to reduce climate change emissions.

Each agency represented on the Climate Action Team has agreed to incorporate environmental justice considerations into their efforts to support the directives of the Executive Order. To the extent possible, environmental justice considerations are included in the agencies' work plans to implement strategies that reduce climate change emissions. Where appropriate, the work plans also emphasize the scenario analysis effort and the evaluation of cap and trade options.

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1 INTRODUCTION

California has a long history of environmental leadership. Motivated by the stunning natural beauty of our coastline, inland valleys, forests and mountains, as well as by the public health and environmental challenges brought on by increasing levels of pollution, California's citizens have repeatedly called for and supported measures to protect California's environmental heritage. Our political leadership and governmental institutions have responded with a variety of initiatives that restore, protect, and enhance the environment to ensure public health, environmental quality, and economic vitality. Often these California initiatives have provided a benchmark and template for further action both nationally and internationally.

This tradition of environmental leadership continues to this day. In 2005, recognizing that global warming will impose compelling and extraordinary impacts on California, the Governor signed Executive Order S-3-05 which established climate change emission reduction targets for the state and set in motion a process to ensure the targets are met. This Executive Order also recognized the importance of preparedness in that it directed the Secretary of the California Environmental Protection Agency (Cal/EPA) to lead an effort to evaluate the impacts of climate change on California and to examine adaptation measures that would best prepare the state to respond to the adverse consequences of climate change.

1.1 Organization of the Report

The report begins (Section 2) with an overview of the scientific evidence regarding climate change and its potential effects in California. Section 3 outlines the long history of previous actions that California has taken to understand and address the threat of climate change. Section 4 provides an overview of the scenario analysis that was done to evaluate the impacts of climate change on California, potential adaptation measures that can be taken to best respond to those impacts, and an economic assessment of the impacts. Section 5 presents the Climate Action Team recommendations regarding strategies the state should pursue to reduce climate change emissions.

Section 6 outlines cap and trade options for the state and includes a discussion of design choices that need to be further evaluated prior to adoption of a cap and trade program for the state. Section 7 discusses all possible emission reduction implementation options that were considered by the Climate Action Team, including cap and trade. Section 8 covers a broad assessment of the economic implications of state actions to reduce climate change emissions. Section 9

looks specifically at potential impacts on minority and low-income communities. Section 10 contains the Climate Action Team's recommendations to the Governor and the Legislature.

2 CLIMATE CHANGE OVERVIEW

The Earth's climate has always evolved—the extremes of the 100,000-year ice-age cycles in both climate and climate change emissions over the last half million years are well documented. The period of the last 10,000 years has been warm and stable, and the last millennium, over which current societies have developed, has been one of the most stable climates observed. Yet, during the 20th century, we have observed a rapid change in the climate and climate change pollutants that is attributable to human activities.

These recent changes in climate change pollutants far exceed the extremes of the ice ages, and the global mean temperature is warming at a rate that cannot be explained by natural causes alone. Human activities are directly altering the chemical composition of the atmosphere through the buildup of climate change pollutants.

It is true that levels of natural climate change pollutants have fluctuated in the past. However, there are several reasons for attributing the rise in climate change pollutants to anthropogenic, rather than natural emissions. The first indicator comes from comparing the current increase with changes that have occurred in the past.

At the end of the last ice age, the concentration of CO_2 increased by around 100 ppm (parts per million) over about 8,000 years, or approximately 1.25 ppm per century. Since the start of the industrial revolution, the rate of increase has accelerated markedly. The rate of CO_2 accumulation currently stands at around 150 ppm/century—more than 200 times faster than the background rate for the past 15,000 years.

The heat-trapping property of climate change pollutants is undisputed. Although there is uncertainty about exactly how and when the Earth's climate will respond to increasing concentrations of climate change pollutants, combining observations with climate models indicates that detectable changes are underway. There most likely are and will continue to be changes beyond global mean warming, such as changes in regional temperature extremes, precipitation, soil moisture, and sea level, all of which could have significant adverse effects on many ecological systems, as well as on human health and the economy.

This section first presents the causes and projections for climate change, then discusses climate change pollutants. It includes a definition of global warming potentials and climate change pollutants. The section concludes with a brief discussion of abrupt climate change.

2.1 Climate Change Causes and Projections

Climate change is a shift in the "average weather" that a given region experiences. This is measured by changes in the features that we associate with weather, such as temperature, wind patterns, precipitation, and storms. Global climate change means change in the climate of the Earth as a whole. The Earth's natural climate has always been, and still is, constantly changing. The climate change we are seeing today, however, differs from previous climate change in both its rate and its magnitude.

The temperature on Earth is regulated by a system commonly known as the "greenhouse effect." Naturally occurring climate change pollutants, primarily water vapor, CO_2, CH_4, and N_2O, absorb heat radiated from the Earth's surface. As the atmosphere warms, it in turn radiates heat back to the surface to create the greenhouse effect. The Earth's surface temperature would be about 34°C (61°F) colder than it is now if it were not for the natural heat trapping effect of climate change pollutants like CO_2, CH_4, N_2O, and water vapor.

Human activities are exerting a major and growing influence on some of the key factors that govern climate by changing the composition of the atmosphere and by modifying the land surface. The concentration of CO_2 in the atmosphere has risen about 30 percent since the late 1800s (National Assessment Synthesis Team [NAST], 2001). This increase has resulted from the burning of coal, oil, and natural gas, and the destruction of forests around the world to provide space for agriculture and other human activities.

Global projections of population growth and assumptions about energy use indicate that the CO_2 concentration will continue to rise, likely reaching between two and three times its late-19th-century level by 2100. Figure 2-1 shows the atmospheric CO_2 concentration from year 1000 to year 2000 from ice core data and from direct atmospheric measurements during the past few decades. Projections of CO_2 concentrations for the period 2000 to 2100 are based on model predictions.

Figure 2-1: Past and future CO_2 atmospheric concentrations. (Source: IPCC 2001 Synthesis report)

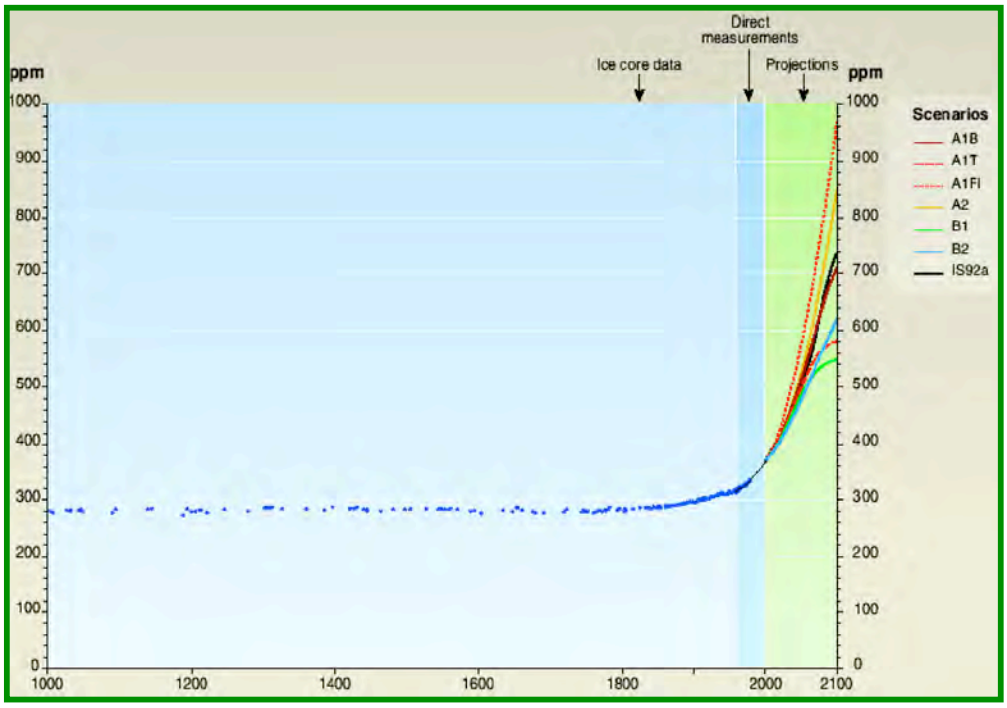


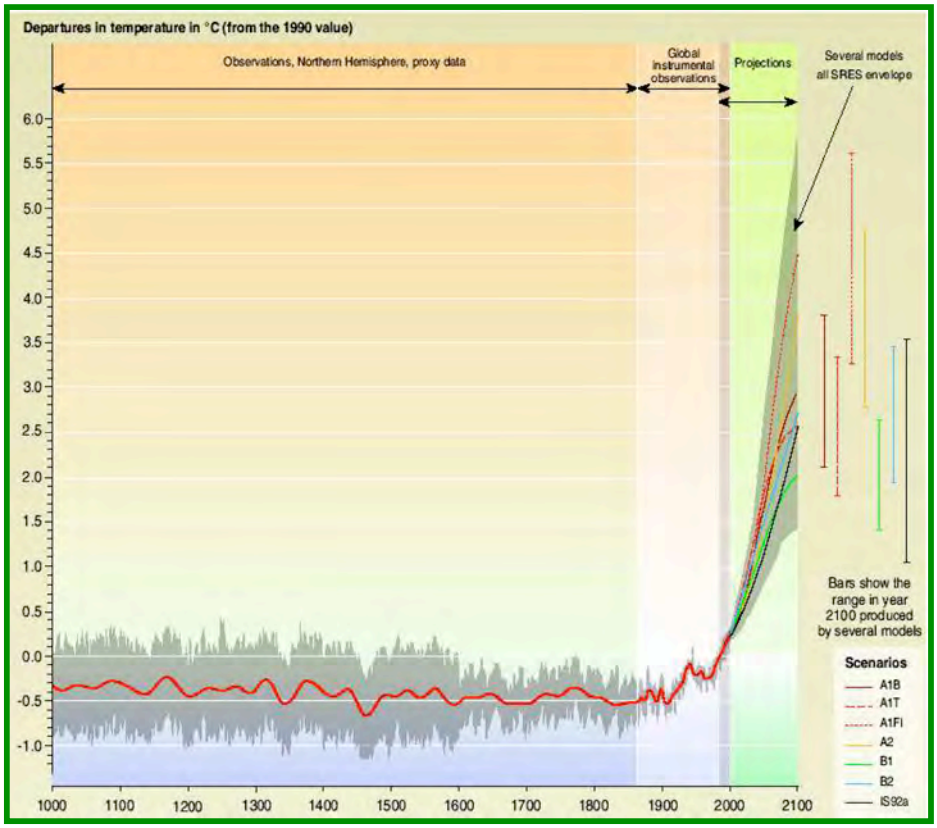
Figure 2-1 shows variations of the Earth's surface temperature for years 1000 to 2100. From year 1000 to year 1860 variations in average surface temperature of the Northern Hemisphere are reconstructed from proxy data (tree rings, corals, ice cores, and historical records). The line shows the 50-year average; the gray region, the 95 percent confidence limit in the annual data.

For the period 1860 to 2000, the figure shows variations in observations of globally and annually averaged surface temperature from the instrumental record; the line shows the decadal average. For 2000 to 2100, projections of globally averaged surface temperature are shown for several model scenarios using a global climate model.

The Third Assessment Report of the International Panel on Climate Change (IPCC, Synthesis Report, 2001) and the National Research Council of the National Academies (NRC, 2001) conclude that the global climate is changing at a rate unmatched in the past 1,000 years. The IPCC assessment cites new and

stronger evidence that most of the global warming observed over the last 50 years is attributable to human activities and that anthropogenic climate change will persist for many centuries.

Figure 2-2. Variations of the Earth's surface temperature: years 1000 to 2100 (Source: IPCC 2001 Synthesis report)



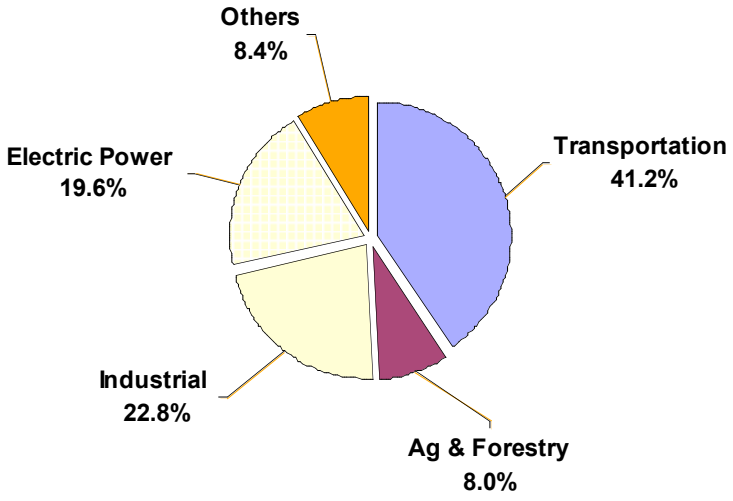
Many sources of data indicate that the Earth is warming faster than at any time in the previous 1,000 years. The global mean surface temperature has increased by 1.1°F since the 19th century (IPCC Synthesis report, 2001). The 10 warmest years of the last century all occurred within the last 15 years.

For example, 2002 and 2003 are tied as the second warmest years on record, according to a year-end review of climate data by the National Oceanic and Atmospheric Administration. Both the IPCC (2001) and the NAST (2001) reports project that warming in the 21st century will be significantly larger than in the 20th century. Scenarios examined in these assessments indicate that temperatures in the U.S. will rise by about 5° to 9°F (3° to 5°C) on average in the next 100 years.

2.2 Climate Change Emission Sources and Pollutants

As shown in Figure 2-3, fossil fuel consumption in the transportation sector was the single largest source of California's climate change emissions in 2002, with the industrial sector as the second-largest source. Electricity production, from both in-state and out-of-state sources, was the third-largest source. Agriculture, forestry, commercial, and residential activities comprised the balance of California's climate change emissions (CEC, 2005).

Figure 2-3: Sources of California's Climate Change Emissions, 2002 Expressed in Terms of CO_2 Equivalence (adapted from CEC, 2005).

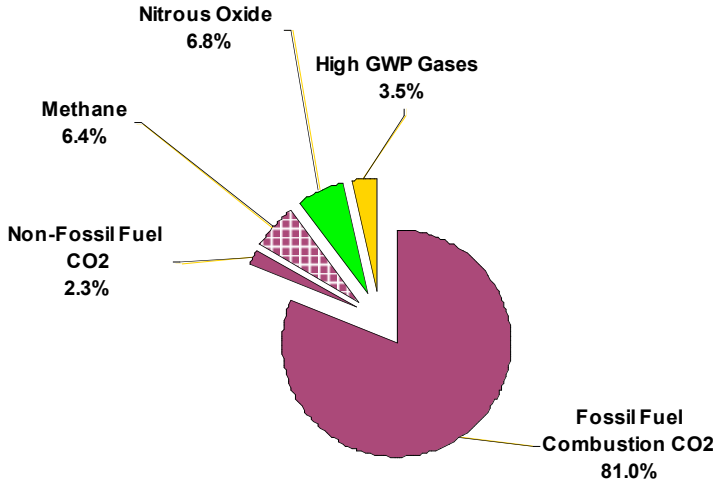


As previously indicated, human activities are altering the chemical composition of the Earth's atmosphere through the release and build-up of climate change emissions. However, climate change pollutants such as water vapor, CO2, CH4, N2O, and O3 can also be associated with natural sources. Conversely, several classes of halogenated substances that contain fluorine, chlorine, or bromine are also climate change emissions, but they are, for the most part, solely a product of industrial activities.

Figure 2-4 provides a distribution of California anthropogenic climate change pollutants by gas in 2002, expressed in terms of CO_2 equivalence. In addition, there are a number of other pollutants such as carbon monoxide, nitrogen

oxides, and aerosols that have direct or indirect effects on terrestrial or solar radiation absorption. Individual climate change species are briefly discussed in the following section.

Figure 2-4: California Composition of Gross Climate Change Pollutants, 2002 Expressed in Terms of CO_2 Equivalence (adapted from CEC, 2005).



2.2.A Carbon Dioxide (CO_2)

In the atmosphere, carbon generally exists in its oxidized form, as CO_2. Increased CO_2 concentrations in the atmosphere have been primarily linked to increased combustion of fossil fuels. Fossil fuel combustion accounted for 98 percent of gross California CO_2 emissions. California's total CO_2 emissions from fossil fuel combustion in 2002 were 360 million metric tons CO_2, which accounts for approximately 7 percent of the U.S. emissions from this source. The transportation sector accounted for the largest portion of CO_2 emissions with gasoline consumption accounting for the greatest portion of emissions.

2.2.B Methane (CH_4)

Methane accounted for approximately 6 percent of gross 2002 climate change emissions in California (CO_2 equivalent). Methane is produced during anaerobic decomposition of organic matter in biological systems. Decomposition occurring in landfills accounts for the majority of anthropogenic CH_4 emissions in California and in the United States as a whole. Agricultural processes such as enteric fermentation, manure management, and rice cultivation are also significant sources of CH_4 in California.

2.2.C Nitrous Oxide (N_2O)

Nitrous oxide emissions accounted for nearly 7 percent of climate change emissions (CO_2 equivalent) in California in 2002. The primary sources of anthropogenic N_2O emissions in California are agricultural soil management and fossil fuel combustion in mobile sources.

Nitrous oxide is a product of the reaction that occurs between nitrogen and oxygen during fuel combustion. Both mobile and stationary combustion emit N_2O, and the quantity emitted varies according to the type of fuel, technology, and pollution control device used, as well as maintenance and operating practices. U.S.EPA estimates from 2003 suggest that in 2001, N_2O emissions from mobile combustion were 13 percent of U.S. N_2O emissions, while stationary combustion accounted for 3 percent.

2.2.D Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulfur Hexafluoride (SF_6)

HFCs, PFCs and SF_6 accounted for about 3.5 percent of gross 2002 climate change emissions in California (CO_2 equivalent). HFCs are primarily used as substitutes for ozone-depleting substances (ODS) regulated under the Montreal Protocol. PFCs and SF_6 are generally emitted from various industrial processes including aluminum smelting, semiconductor manufacturing, electric power transmission and distribution, and magnesium casting. There is no aluminum or magnesium production in California; however, the rapid growth in the semiconductor industry leads to greater use of PFCs.

2.2.E Other Radiatively Important Gases

In addition, there are a number of man-made pollutants, emitted primarily as by-products of combustion (both of fossil fuels and of biomass), that have indirect effects on terrestrial or solar radiation absorption by influencing the formation or destruction of other climate change emissions. These include carbon monoxide (CO), nitrogen oxides (NO_X), nonmethane volatile organic compounds (NMVOCs), and sulfur dioxide (SO_2).

These compounds, regulated in the U.S. and California pursuant to the Clean Air Act, are often referred to as “criteria pollutants.” The criteria pollutants are reactive compounds, and they tend to remain in the atmosphere for a much shorter time (typically hours to months) than the previously discussed gases. As shown in Table 2-1, CO_2, N_2O, CH_4, and HFC-134a have atmospheric lifetimes ranging from a century to 10 years.

The sequence of reactions that removes CO, NO_X, and NMVOCs from the atmosphere, however, tends to promote the formation of tropospheric O_3 which is also a potent climate change emission. At present, there is large scientific uncertainty in estimating the radiative forcing effects of criteria pollutants.

2.2.F Aerosols

Aerosols are extremely small particles or liquid droplets found in the atmosphere. Various categories of aerosols include naturally produced aerosols (e.g., soil dust, sea salt, biogenic aerosols, and volcanic aerosols), and anthropogenic aerosols (e.g., sulfates, ammonium nitrate, industrial dust, and carbonaceous aerosols including black carbon and organic carbon). Anthropogenic aerosols are derived directly or indirectly from transportation, coal combustion, cement manufacturing, waste incineration, and biomass burning.

Aerosols affect radiative forcing in both direct and indirect ways: directly by scattering and absorbing solar and thermal infrared radiation; and indirectly by altering the cloud properties and atmospheric heating rates that in turn modify the formation, precipitation efficiency, and radiative properties of clouds. The effect of aerosols on regional and global climate is complex: in general, sulfate aerosols enhance the reflection of sunlight and cool the Earth, while black carbon aerosols enhance the absorption of sunlight and warm the Earth.

Understanding the role of aerosols in climate change requires inclusion of realistic representations of aerosols and their radiative forcings in climate models. However, uncertainty in aerosol radiative forcing arises because neither emissions, atmospheric abundance, optical properties, nor indirect effects are well characterized. The IPCC (2001) and the NACIP (2002) have identified the total (direct and indirect) radiative forcing due to aerosols, and in particular light absorbing aerosols, as one of the most uncertain components of climate change models.

2.2.G Water Vapor

It should be noted that just because water vapor is the most important contributor to the natural greenhouse effect does not mean that human-made climate change emissions are unimportant. However, human activities do not seem to be appreciably changing the atmospheric concentration of water vapor in any direct way on the global average.

A simple comparison of the relative greenhouse efficiencies of water vapor and CO_2 quickly becomes problematic because water vapor enters the climate system mostly as a "feedback" gas. Further, water stays in the atmosphere for a

few days, while other climate change emissions linger for decades or centuries. The overall impact of water vapor with respect to global climate change is not well understood as it can lead to both warming (absorption of long-wave radiation from Earth) and cooling (cloud formation/reflection of solar radiation).

2.3 Global Warming Potentials

Radiative forcing is often defined as a net imbalance in energy flux in the atmosphere, and is expressed in watts per square meter (W/m^2), i.e. heat per area of the Earth's surface. Radiative forcing of the surface-troposphere system, resulting, for example, from a change in climate change pollutant concentrations, is the change in the balance between radiation coming into the atmosphere and radiation going out. A positive radiative forcing tends, on average, to warm the surface of the Earth, and negative forcing tends, on average, to cool the surface.

The impact of a climate change pollutant upon the atmosphere is related not only to radiative properties of the gas and its initial abundance, but also to the length of time the climate change pollutants remain in the atmosphere. Radiative properties control the absorption of radiation per kilogram of gas present at any instant, but the lifetime of the gas controls how long an emitted kilogram remains in the atmosphere and hence its cumulative impact on the atmosphere's thermal budget.

Gases in the atmosphere can contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself is a climate change pollutant. Indirect radiative forcing occurs when chemical transformations of the original gas produce other climate change pollutants, when a gas influences the atmospheric lifetimes of other gases, and/or when a gas affects atmospheric processes that alter the radiative balance of the Earth (e.g., cloud formation).

The concept of a Global Warming Potential (GWP) has been developed in parallel to the concept of ozone depletion potential developed under the Montreal Protocol to compare the ability of each climate change pollutant to trap heat in the atmosphere relative to another gas.

Carbon dioxide, as the primary anthropogenic climate change pollutant, has been chosen as the reference gas. GWP is defined as the ratio of the time-integrated radiative forcing from the release of 1 kilogram of a trace substance relative to that of 1 kg of CO_2 (IPCC 2001). While any length of integration can be selected, the 100-year GWPs are recommended by the IPCC and will be employed for policy-making and reporting purposes.

GWP values allow a comparison of the impacts of emission changes (reductions or increases) of different gases. According to the IPCC (2001), GWPs typically have an uncertainty of ±35 percent. In addition to communicating climate change pollutants in units of mass, we have also chosen to use GWPs to reflect their inventories in CO_2-equivalent terms because it effectively places all of the climate change pollutants on the same comparative scale.

Table 2-1 lists GWPs for CO_2, CH_4, N_2O, and HFC-134a for the 20-, 100-, and 500-year time horizons. It should be noted that when the lifetime of the species in question differs substantially from the response time of CO_2 (nominally about 150 years), then the GWP becomes very sensitive to the choice of time horizon. The GWP concept is only relevant for compounds that have sufficiently long lifetimes to become globally well-mixed. Therefore, short-lived gases and aerosols with varying atmospheric distributions and lifetimes pose a problem in the simple GWP framework.

Table 2-1. Numerical Estimates of Global Warming Potentials Compared with CO_2 (Kilograms of Gas Per Kilogram of CO_2 adapted from IPCC 2001).

Climate Change Pollutants	Lifetime (years)	Global Warming Potential		
		20 years	100 years	500 years
CO_2	~150	1	1	1
CH_4	12	62	23	7
N_2O	114	275	296	156
HFC-134a	14	3,300	1,300	400

2.4 Abrupt Climate Change

When most people think about climate change, they imagine gradual increases in temperature and only marginal changes in other climatic conditions, continuing indefinitely or even leveling off at some time in the future. It is assumed that human societies can adapt to gradual climate change. However, recent climate change research has uncovered a disturbing feature of the Earth's climate system: it is capable of sudden, violent shifts. This is a critically important realization.

Climate change will not necessarily be gradual, as assumed in most climate change projections, but may instead involve relatively sudden jumps between very different states. A mounting body of evidence suggests that continued increasing climate change emissions may push the oceans past a critical threshold and into a drastically different future.

Abrupt climate change is the subject of reports commissioned by the National Academy of Science (NRC 2002) and the U.S. Department of Defense (Schwartz and Randall, 2003). Thus, in addition to the gradual (albeit accelerated) climate changes projected by current climate models, Californians need to be aware of the possibility of much more sudden climate shifts.

2.5 Summary

There is little doubt that climate change is happening today, that human-caused increases in the atmospheric abundance of climate change pollutants are a large

cause of that change, and the 21st century climate change will be greater than that we have experienced in the 20th century. Much of that projected climate change is as yet unrealized warming from the climate change pollutants in the atmosphere today. Nevertheless, actions taken to reduce climate change emissions today can reduce the magnitude and rate of climate change this century.

There is no scientific uncertainty about the fact that human activities have increased the atmospheric abundance of climate change pollutants. The uncertainties center on predicting exactly what the climate changes will be in various local areas of the Earth and what the effects of clouds will be in determining the rate at which the mean temperature will increase.

There are also uncertainties associated with characterizing the timing and magnitude of other consequences of a warmer planet: sea level rise, spread of certain diseases out of their usual geographic range, the effect on agricultural production, water supply, sustainability of ecosystems, increased strength and frequency of storms, extreme heat events, air pollution episodes, and the impact of these effects on human health and the economy.

3 CALIFORNIA ACTIONS TO ADDRESS CLIMATE CHANGE

The State of California has traditionally been a pioneer in efforts to reduce air pollution, dating back to 1963 when the California New Motor Vehicle Pollution Control Board adopted the nation's first motor vehicle emission standards. California likewise has a long history of actions undertaken in response to the threat posed by climate change.

Beginning in 1988, legislation was enacted that directed the California Energy Commission, in consultation with the Air Resources Board and other agencies, to study the implications of global warming on California's environment, economy, and water supply.

This effort continued with Governor Schwarzenegger's June 2005 Executive Order creating climate change emission reduction targets for the state. The Order requested a report that specifically addresses the impacts of climate change on the state and includes adaptation measures the state can implement to best respond. California state government has consistently recognized the necessity for state action on climate change to protect California's interests.

3.1 Summary of California Activities Underway

California has a long history of environmental leadership and has continued that leadership in the efforts to reduce climate change emissions. Table 3-1 indicates those strategies that are underway in California.

Section 2.1 asserted that the transportation sector is the largest source of emissions in California. The motor vehicle standards of the Air Resources Board (ARB) provide significant emission reductions in this sector in the 2020 time frame. Two other key strategies in the state are the Renewable Portfolio Standard and the Energy Efficiency Programs. These strategies have been instrumental in California's efforts to provide energy security for the state and have also provided significant climate change emission reductions. The state's Energy Efficiency Programs have resulted in a stable per-capita energy use in the state even while California's economy has soared.

It is important to note that these strategies, though underway, will require continuing efforts by the responsible agencies as well as strong leadership to ensure they remain in place. Governor Schwarzenegger has pledged his support of the ARB's motor vehicle regulations and the acceleration of the Renewable Portfolio Standard. The Governor's support and the continuing support of the Legislature will be essential as the state implements these strategies successfully.

Table 3-1 Emission Reduction Strategies Underway in California

Agency Responsible	Climate Change Emission Reductions (Million Tons CO_2 Equivalent)	
Strategies	2010	2020
Air Resources Board		
Vehicle Climate Change Standards	1	30
Diesel Anti-idling	1	2
Public Utilities Commission		
Accelerated Renewable Portfolio Std to 33% by 2020 (including load-serving entities [LSE])	5	11
California Solar Initiative	0.4	3

Investor Owned Utility Energy Efficiency Programs(including LSEs)	4	8.8
Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Energy Commission		
Building Energy Efficiency Standards	1	2
Appliance Energy Efficiency Standards	3	5
Fuel-efficient Replacement Tires & Inflation Programs	1.5	1.5
State and Consumer Services and Cal/EPA		
Green Buildings Initiative	0.5	1.8
Air Resources Board andCal/EPA		
Hydrogen Highway	Not yet estimated	
Total Potential Emission Reductions	22	68

3.2 Executive Order S-3-05

On June 1, 2005, Governor Schwarzenegger signed Executive Order S-3-05 (EO) during the United Nations World Environment Day event in San Francisco. The EO established climate change emission reduction targets for California and was heralded in the nation and around the world as a landmark event signaling that California is taking a leadership role in the United States in addressing the issue of climate change. The Governor said in his remarks preceding the signing of the EO, "…the debate is over. We know the science. We see the threat. And we know the time for action is now."

This quote appeared in the media throughout the world. Internationally the developed nations agree that the issue of climate change must be addressed. It is no exaggeration to say that the world had been waiting for a strong signal that the state which has led a nation on so many public health and environmental issues would continue that leadership in addressing climate change.

The targets established by the EO are shown in Table 3-2. The 2010 and 2020 targets are based on an ambitious estimate of how much the state can reduce emissions with strong top-down leadership and a coordinated effort amongst various state agencies. CalEPA worked with the ARB, CEC and Tellus, a technical contractor, to develop the targets in the 2010 and 2020 timeframes.

The 2050 target is based on emission reductions the science indicates will be necessary from all developed nations to ensure protection of the planet in the 100-year time frame.

Table 3-2. California's Climate Change Emission Reduction Targets

By 2010, Reduce Emissions to 2000 Levels*

By 2020, Reduce Emissions to 1990 Levels**

By 2050, Reduce Emissions to 80% Below 1990 Levels

* 59 Million Tons Reduction, 11% Below Business As Usual

** 145 Million Tons Reduction, 25% Below Business As Usual

In addition to setting targets for the state, the EO placed Cal/EPA in the lead to coordinate efforts to meet these targets among the following agencies: Business, Transportation and Housing Agency (BT&H), Department of Food and Agriculture (CDFA), Energy Commission (CEC), Resources Agency, and Public Utilities Commission (PUC). A coordinated effort is essential to success in climate change emission reduction strategies. Programmatic, incentive-based, or market-based strategies will require the efforts of agencies whose purview stretches across all sectors of the economy, from transportation to energy to agriculture to waste management.

Finally, the EO directed Cal/EPA to lead an evaluation of the impacts of climate change in California, mitigation strategies to reduce emissions, and adaptation measures that can be taken by the state to best respond to the adverse impacts of climate change. This effort is built upon the work of the CEC under the Public Interest Energy Research plan.

The CEC is currently about half way through a five-year plan that responds to many of the same directives included in the EO. Cal/EPA worked with CEC and other agencies to incorporate a broader scope and provide the Governor and Legislature with a mid-point estimate of what California can expect as a result of

climate change and how the state can best respond to the adverse consequences.

3.3 Climate Action Team

In response to the EO, the Secretary of Cal/EPA created the Climate Action Team (CAT). The CAT includes knowledgeable representatives from Air Resources Board; Business, Transportation, & Housing; Department of Food and Agriculture; Energy Commission; California Integrated Waste Management Board (CIWMB), Resources Agency, and Public Utilities Commission (PUC). The CAT has prepared a recommended list of strategies for the state to pursue to reduce climate change emissions in the state. This list in described in detail in Section 5. The CAT has also contributed to and reviewed the scenario analysis described in Section 4.

There are two subgroups of the CAT, the cap and trade subgroup and the scenario analysis subgroup. Both subgroups are made up of representatives appointed by the CAT and experts as appropriate. The cap and trade subgroup was created by the Secretary of Cal/EPA because of the cross-cutting nature of a cap and trade program for the state. The scenario analysis subgroup addressed the directive in the EO to evaluate the impacts of climate change on the state and adaptation measures that can be taken by the state to best prepare for the adverse consequences of climate change.

4 Scenario Analysis

In California and throughout western North America, signs of a changing climate are evident. Over the last 50 years, observations reveal trends toward warmer winter and spring temperatures, a smaller fraction of precipitation falling as snow instead of rain, a decrease in the amount of spring snow accumulation in lower and middle elevation mountain zones, an advance in snowmelt of 5 to 30 days earlier in the spring, and a one- to two-week shift in the timing of spring flower blooms.

These changes are consistent with much broader scale global measures. From 1900 through 1970, the average global temperature rose by about 0.1^{o}F (0.06 ^{o}C) per decade, but since then the rate of warming has increased markedly, to about 0.5^{o}F (0.3^{o}C) per decade. During the last 1,000 years, available observations suggest that the 10 warmest years all occurred after 1990. Much of the warming during the last four decades is attributable to the increasing atmospheric concentrations of climate change emissions due to human activities.[1]

It is now evident that even if actions could be taken to immediately curtail climate change emissions, the potency of emissions that have already built up, their long atmospheric lifetimes, and the inertia of the Earth's climate system could produce as much as 1.1°F (0.6°C) of additional warming.[2] As a result, some impacts from climate change are now unavoidable.

For example, studies show that some unique ecosystems, such as coral reefs, and those in artic and alpine regions, have been or will be severely damaged or lost as a result of climate changes already underway.[3] However, depending on the amount of climate change emissions emitted over the next few decades, an opportunity remains to avoid the most severe impacts that are expected with greater rises in temperature.

The scientific community is striving to determine how vulnerable human society and the earth systems on which it depends are to future climate changes. Although no consensus has been reached as to what constitutes "dangerous" climate change, there has been increasing warning about the impacts of global average temperatures rising over 3.6°F (2°C). These include a rapid increase in global hunger, health risks, and water shortages. Temperature rises above 3.7°F (2°C) also increase the risk of abrupt climatic changes such as rapid sea level rise from the disintegration of the West Antarctic Ice Sheet.[4]

Linking specific temperature changes—such as the proposed 3.6°F (2°C) dangerous threshold—with particular levels of global warming emissions in the atmosphere, is complicated. Although all climate models project increased temperatures as a result of higher concentrations of greenhouse gas emissions, different models show varying sensitivity of the earth's climate system to changes in atmospheric greenhouse gas concentrations.

For example, temperature rises between 2.7°–8.1°F (1.5°–4.5°C) have been projected for a doubling of CO_2 concentration above pre-industrial levels. This wide range of temperature projections is the result of differences in modeling the climate system, particularly those related to the characterization of clouds that result in different projections of climate sensitivity to changes in greenhouse gas concentrations.

Society can neither control nor precisely determine the sensitivity of the earth's climate system to rising climate change emission concentrations. As a result, it is critical to carefully consider implications of a range of climate sensitivities when evaluating the risks of climate change and devising policies to manage the one factor we can control: our own climate change emissions.

For example, the United Kingdom (UK) adopted a maximum of 550 ppm CO_2 atmospheric concentration target and determined that reaching this target would require the industrialized world to decrease emissions by approximately 60 percent by the year 2050.

However, it is unclear if this 550 ppm target will keep global temperatures below a 3.6°F (2°C) dangerous threshold. Although the Intergovernmental Panel on Climate Change (IPCC) range of climate sensitivity suggests that the UK concentration target is compatible with a 3.6°F degree temperature target, the 550 ppm assumes a low-climate sensitivity. This implies that a lower concentration target, and therefore greater emission reductions, will likely be needed.

This chapter summarizes findings of recent analyses that explore the implications of various climate change scenarios for California. The studies focus on comparing the implications of different scenarios of climate change emissions given a range of climate sensitivities. The projections reported are linked to three climate change emission scenarios—a lower emissions, medium-high emissions, and higher emissions scenario.

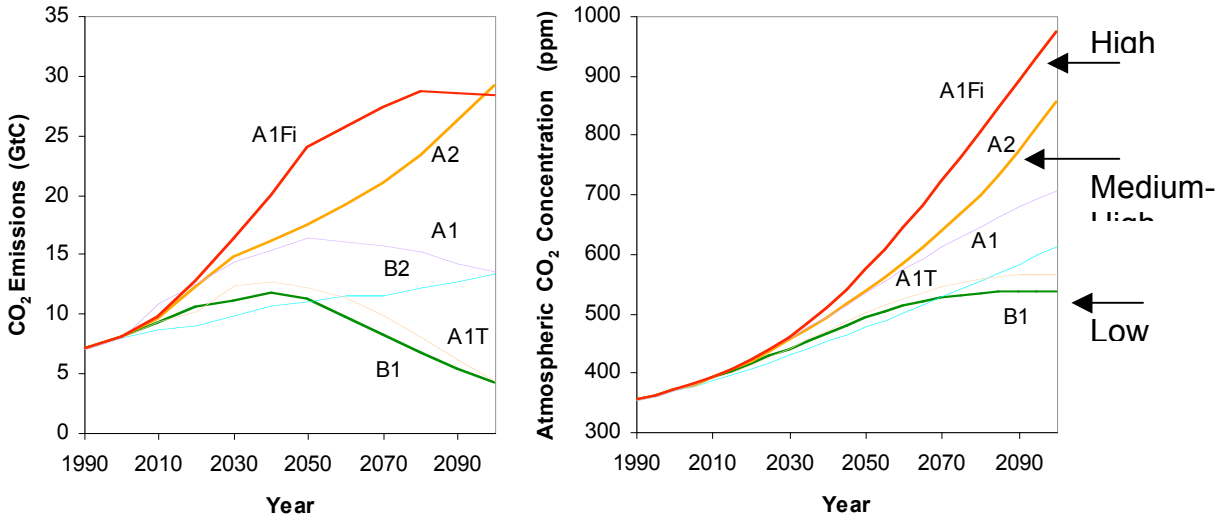
The sensitivity of the climate system to increasing atmospheric concentrations of emissions is explored by comparing the temperature projections from three different global climate models, each containing somewhat different representations of some crucial physical processes that result in levels of climate sensitivity.

The following section describes the emission scenarios and climate projections reported in this chapter. Other sections report on the projected impacts of the specific climate projections across six sectors—coasts, water resources, agriculture, forests/fire, public health, and electricity. The chapter concludes with a discussion of the implications of these projections for mitigation and adaptation.

4.1 Climate Change Scenarios 5

The Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (SRES) developed a set of possible future emissions scenarios based on different assumptions about global development paths (Figure 4-1). This section relies upon the results from recent analysis for California of three SRES emission scenarios—a higher emissions scenario (A1Fi), a medium-high emission scenario (A2), and lower emission scenarios (B1).

Figure 4-1. Special Report on Emissions Scenarios



The highest emissions scenario (A1fi) represents a world of rapid fossil-fuel-intensive economic growth, global population that peaks mid-century then declines, and the introduction of new and more efficient technologies toward the end of the century.

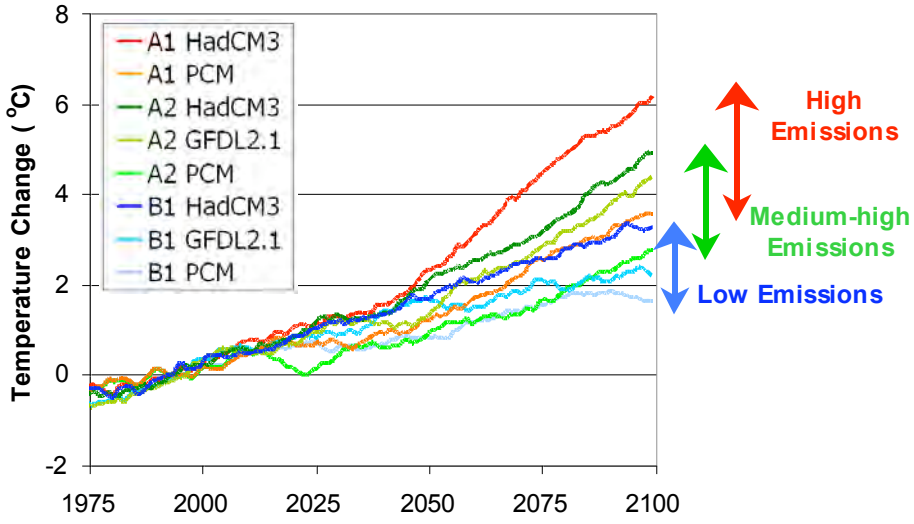
The medium-high emissions scenario (A2) projects continuous population growth with slower economic growth and technological change than in the other scenarios. In contrast, the lowest emissions scenario (B1) characterizes a world with population growth similar to the highest emissions scenarios, but with rapid changes towards a service and information economy and with the introduction of clean and resource-efficient technologies.6

To capture a range of uncertainty among climate models, this chapter reports on projections from three state-of-the-art global climate models (GCM)—a low-sensitivity model, the Parallel Climate Model (PCM1)7 from the National Center for Atmospheric Research (NCAR) and the Department of Energy (DOE) groups; a medium-sensitivity model, the Geophysical Fluids Dynamic Laboratory (GFDL) CM2.1 (NOAA Geophysical Dynamics Laboratory, Princeton NJ)8 model; and the

slightly higher-sensitivity U.K. Met Office Hadley Centre Climate Model, version 3 (HadCM3)9.

Temperature rises significantly over the 21st century, from approximately 3ºF (1.5ºC) in the lower emissions scenario within the lower-sensitivity model and 8ºF (4.5ºC) in the medium-high emissions scenario and the medium sensitivity model, to 10.4ºF (5.8ºC) in the higher-emissions scenario within the most responsive model (Figure 4-2). There is no clear trend in precipitation projections for California over the next century. However the consensus of the recent IPCC model projections, including several models that were not selected for the present study, is for relatively little change in total precipitation, with a tendency toward a slightly greater winter and lower spring precipitation.

Figure 4-2. Change in California Annual Average Daily Mean Temperature Relative to 1971–2000



Change in California annual mean temperature (°C) by year from 1970 to 2100 relative to 1971–2000 average—15-year running mean.

HadCM3 = Hadley Climate Model version 3

PCM = Parallel Climate Model

GFDL2.1 = Geophysical Fluid Dynamics Laboratory model 2.1

A1, A2, and B1 refers to global emission scenarios explained in Section 4. They are higher (A1), medium-high (A2), and lower (B1) emission scenarios.

4.2 Public Health Impacts10

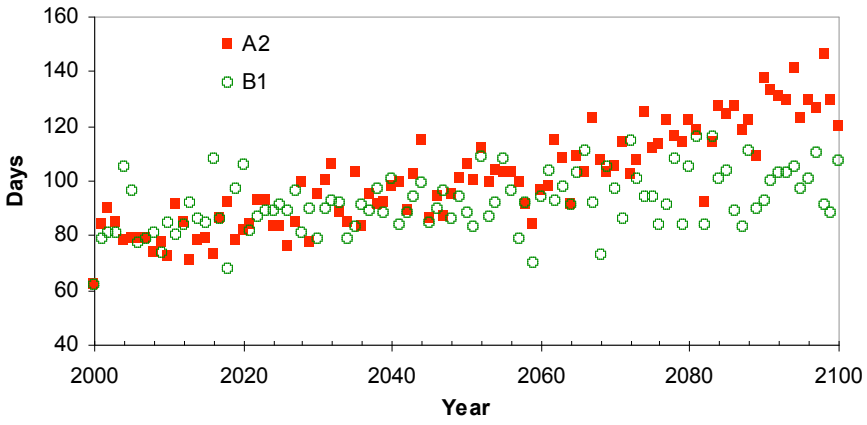
Climate change will affect the health of Californians due to increases in the frequency, duration, and intensity of conditions conducive to air pollution formation, oppressive heat, and wildfires. The primary concern is not change in average climate, but rather the projected increase in extreme conditions that are responsible for the most serious health consequences.

Californians experience the worst air quality in the nation, with annual health and economic impacts estimated at 9,000 deaths and $60 billion per year. Ozone and particulate matter (PM) are the pollutants of greatest concern, and the current control programs for motor vehicles and industrial sources cost about $10 billion per year.

Maximum ozone levels are about double the current air quality standards. Climate change will slow progress toward attainment and increase control costs by boosting emissions, accelerating chemical processes, and raising inversion temperatures during summertime stagnation episodes. The number of days meteorologically conducive to pollution formation may rise by 75 to 85 percent in the high ozone areas of Los Angeles (Riverside) and the San Joaquin Valley (Visalia) by the end of the century under a higher temperature scenario, and by 25 to 35 percent under the lower temperature path.

Figure 4-3. Projected Days at Riverside Meteorologically Conducive to Exceedances of the 1-Hour California Ambient Air Quality Standard for Ozone of 0.09 Parts Per Million (ppm)

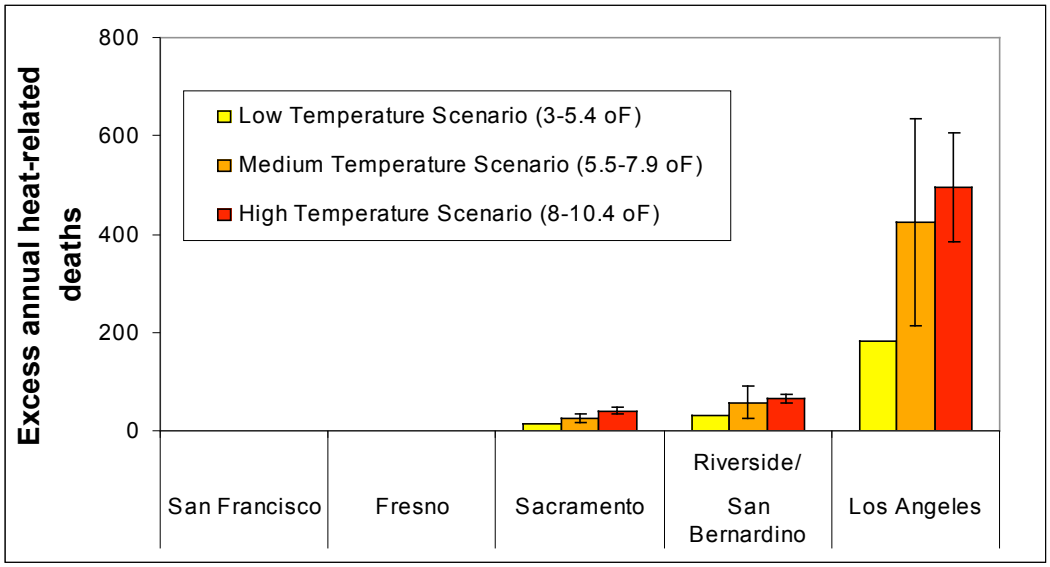
Geophysical Fluid Dynamics Laboratory (GFDL). Source: Kleeman et al., in



In addition, global background ozone (primarily formed from methane and nitrogen oxides from fuel combustion) is projected to increase by 4 to 10 percent (low scenario) to 25 percent (high scenario) by 2100. If background ozone increases by the amount projected for the high scenario, the ozone targets would be impossible to attain in much of California, even with near-zero local emissions. The future trend for PM is not as clear as increasing temperatures reduce some particle types while others show no change or increase slightly. Rainy days, wildfires, global dust storms, humidity, and other factors also affect PM and are the subject of ongoing study.

Analyses of various climate change scenarios project that the future will have a greater number of extremely hot days and fewer extremely cold days, with large increases in heat-related deaths predicted for the five cities studied.

Figure 4-4. Projected Heat-Related Mortality for 2070–2099 relative to 1970–2099



Source: Drechsler et al., in review

For the high temperature scenario, the number of days higher than 90°F in Los Angeles and higher than 95°F in Sacramento will increase to about 100 days by the end of the century, almost twice the increase projected under the lower temperature path. Individuals likely to be the most affected include the elderly, already ill, and poor. On peak demand summer days in 2100, California would need at least 10 percent more electricity, compared to total generation capacity today, for air conditioning alone. Ongoing studies are investigating the relative contribution of air pollution to heat-related death, and refining the air conditioning demand estimates.

Climate change could affect asthma prevalence and attacks, but this is difficult to predict for several reasons. The most common asthma triggers are dust mites and molds, both of which are higher indoors than outdoors and require a relatively humid environment for survival. Consequently, if the climate becomes drier, these triggers will become less important, but they respond to higher humidity with increased growth. Many asthmatics are allergic to various plant pollens. Plants and trees typically have pollination seasons that last a few weeks

per year. To the extent that pollen seasons lengthen or become more intense in response to climate change, increased asthma exacerbation could result.

Climate change has the potential to influence the incidence of infectious disease spread by mosquitoes, ticks, fleas, rodents, and food. More study is needed as research to date has focused on short-term changes in weather patterns (primarily in ambient temperature and rainfall), rather than long-term trends.

4.3 Water Resources Impacts[11]

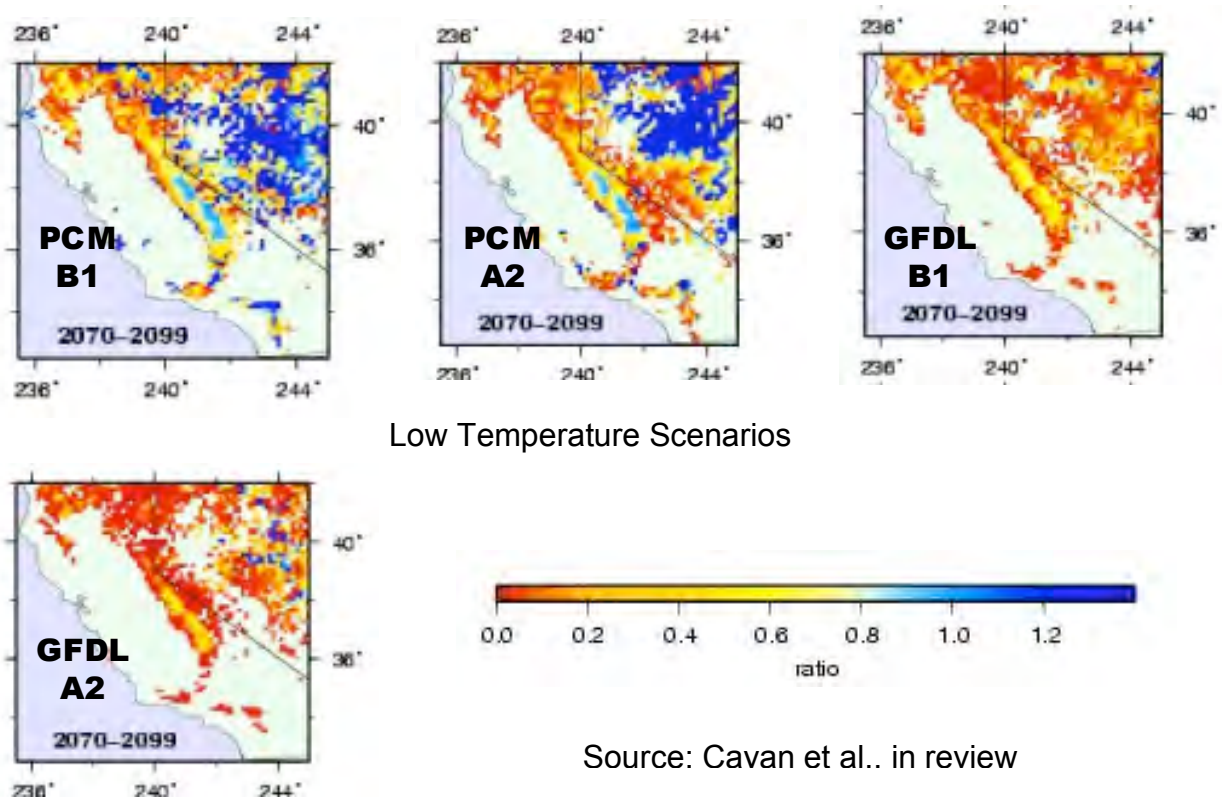
Although precipitation is projected to change only modestly over this century, rising temperatures are expected to lead to diminishing snow accumulation in the Sierra Nevada. Higher temperatures will mean more precipitation will fall as rain instead of snow and the snow that does fall will melt earlier in the spring. Delays in snow accumulation and earlier snowmelt will have cascading affects on water supplies, natural ecosystems, and winter recreation.

Snowpack

The projected losses in snowpack increase with temperature, with the largest in the higher-temperature scenarios.

Each of the simulations shows losses of spring snow accumulation, largely over the Sierra Nevada, to become progressively larger during the 21st century. By the 2035–2064 period, snowpack in the Sierra Nevada could decrease 12 to 47 percent from historical levels under the lower temperature scenarios, and decrease 26 to 40 percent in the higher temperature scenarios. Precipitation changes will play a partial role in the reductions for the lower temperature cases. By the end of century, snowpack could decrease by as much as 90 percent in the higher temperature scenarios, almost double the losses expected under the lower temperature scenarios.

Figure 4-4. April 1 Snow Water Equivalent 2070-2099 fraction of 1961–1990



Low Temperature Scenarios

Source: Cavan et al.. in review

Medium Temperature

Water Supply

Declining snowpack will aggravate the already overstretched water resources in California. The snowpack in the Sierra Nevada provides natural water storage equal to about half the storage capacity in California's major man-made reservoirs. The snowpack holds the winter precipitation in the form of snow and releases it in the spring and early summer as the snow melts. This loss in storage could mean more water shortages in the future. However, the full effect of this storage loss will depend in part on whether reservoirs can be managed to capture the earlier snowmelt while loosing flood control capacity.

Under most scenarios stream flows are projected to decrease slightly by mid-century with more dramatic changes by the end of the century. Flows into the major Sierra Nevada reservoirs could decline between 25 to 30 percent under the medium temperature scenario, almost double the decrease projected under

the lower temperature scenario. However, in one model run, projections suggest a slight increase precipitation and a corresponding rise in projected stream flows.

After mid-century, the change in the volume and timing of runoff reduce the ability of the major projects to deliver water to agricultural users south of the Delta. The projected changes in water supply may be further exacerbated by increasing demand. By the end of century, warmer temperatures are expected to increase the crop demand between 2 and 13 percent in the low and medium temperature scenarios, respectively.

Winter Recreation

Declines in Sierra snowpack will also have widespread implications for winter tourism. Toward the end of the century, in lower temperature scenarios the ski season could shorten by as much as a month while projected climatic changes under the higher temperature scenario suggest that the minimum snow conditions for ski resort operation might be eliminated entirely. Resorts would be forced to rely on snowmaking or move their operations.

4.4 Agriculture Impacts12

Agriculture, along with forestry, is the sector of the California economy that is most likely to be affected by a change in climate. California agriculture is a $68 billion industry.13 California is the largest agricultural producer in the nation and accounts for 13% of all U.S. agricultural sales, including half of the nation's total fruits and vegetables.

Regional analyses of climate trends in agricultural regions of California suggest that climate change is already in motion. During the period 1951 to 2000, the growing season has lengthened by about a day per decade, and warming temperatures have resulted in an increase of 30 to 70 growing degree days per decade, with much of the increase occurring in the spring. Climate change affects agriculture directly through increasing temperatures and rising CO_2 concentrations and indirectly through changes in water availability and pests.

The agriculture sector is likely to bear a disproportionate share of any water scarcity due to any reduced water availability from climate change. A preliminary analysis suggests that a drier climate would impose significant costs on agricultural production in the Central Valley.

Temperature

Temperature influences crop growth through its impact on photosynthesis and respiration, as well as growing season length and water use. Temperature also

serves as a controlling factor for developmental processes, such as flowering and fruit maturation, which may be threatened if lengthening of the growing season introduces asynchrony between the timing of flowering and the life cycle of important insect pollinators.

In general, a warming from a low to a higher temperature raises yield at first but then becomes harmful. Possible effects of excessively high temperature include decreased fruit size and quality for stone fruits, premature ripening and possible quality reduction for grapes, reduced fruit yield for tomatoes, increased incidence of tip burn for lettuce, and similar forms of burn for other crops.

The medium-high and low-emissions scenarios produce changes by the end of this century, wherein the local winter climate approaches critical chill hour thresholds for many species of fruit trees. (Chill hour is the number of hours below a critical temperature.)

Carbon Dioxide (CO_2)

From a variety of studies in the literature, photosynthesis increases when a plant is exposed to a doubling of CO_2. However, whether this translates into increased yield of economically valuable plant product is uncertain and highly variable. Also, elevated CO_2 levels are associated with decreased concentrations of mineral nutrients in plant tissues, especially a decrease in plant nitrogen, which plays a central role in plant metabolism.

Some crops may benefit in quality from an increase in CO_2; for example, the fruit flavor of strawberries improves. Some crops are harmed by an increase in CO_2; for example grain protein in crops decreases and, in the case of wheat, bread-making quality decreases.

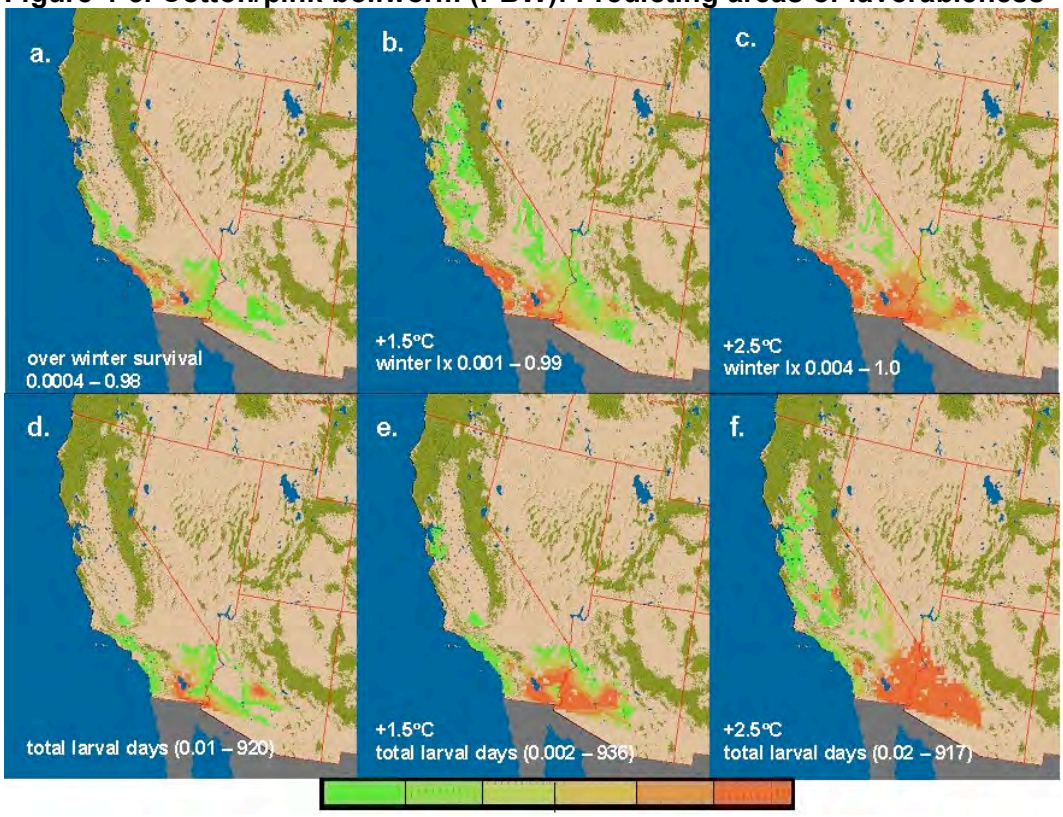
Pests and Weeds[14]

Growth rates of weeds, insect pests, and pathogens are also likely to increase with elevated temperatures, and their ranges may expand. A relatively new area of research involves the use of physiologically-based dynamic models to fully understand the effects of weather (e.g., temperature, rainfall, solar radiation, etc.) on species dynamics.

One of these models was used to estimate the potential impacts of a pest (pink bollworm, or PBW) on cotton cultivation in the state. At the present time this pest is of importance only in the southern desert valleys (e.g., Imperial and Coachella Valleys) because winter frost restricts the invasion of PBW to the million acres of cotton grown in the San Joaquin Valley. However, if winter temperatures rise by

3.6°–4.5°F (2°–2.5°C), as projected under the medium to higher temperature scenarios, the range of PBW of this pest would likely expand northward.

Figure 4-5. Cotton/pink bollworm (PBW): Predicting areas of favorableness



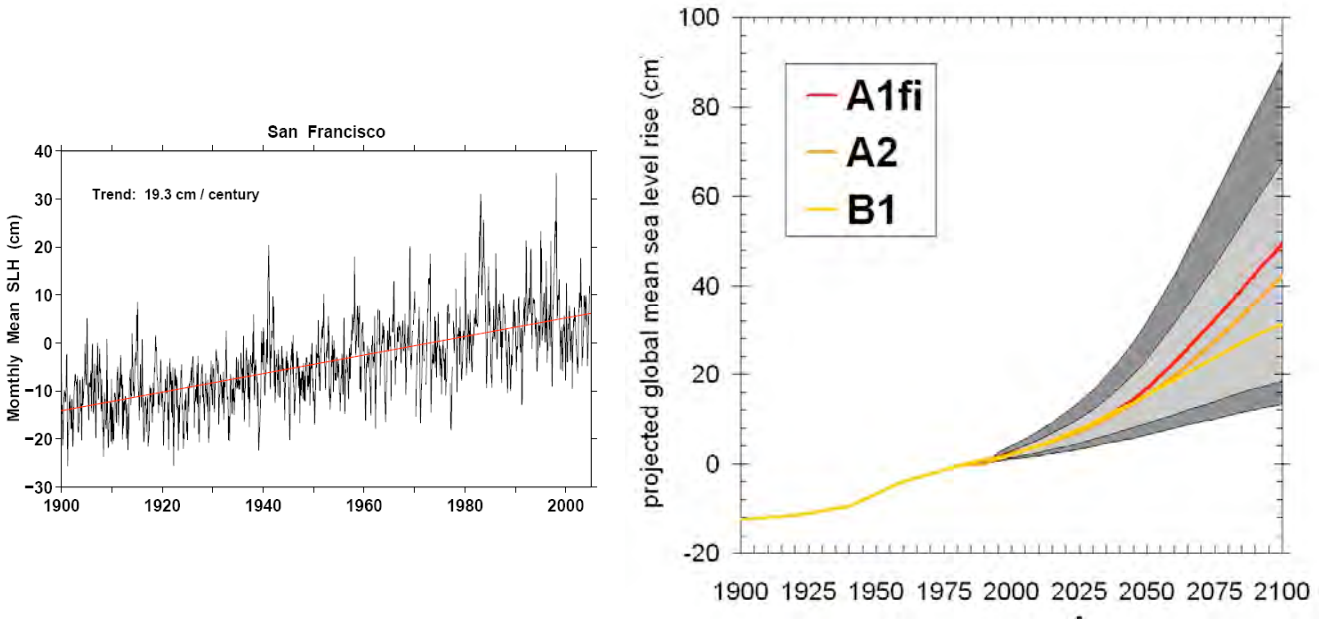
The effects on winter survival (a-c) and total seasonal pest PBW larval densities (larval days, d-e) under current weather (a,d) and with 1.5ºC (b,e) and 2.5ºC (c,f) increases in daily temperatures respectively (Gutierrez et al. in press).

4.5 Coastal Sea Level Impacts15

California's coastal observations and global model projections indicate that California's open coast and estuaries will experience increasing sea levels during the next century. Sea level rise has affected much of the coast of California, including the Southern California coast, the Central California open coast, and the San Francisco Bay and upper estuary. These trends, quantified from a small set of long-duration California tide gages, show upward trends of about 2 mm/year (Figure 4-6). They are very similar to trends estimated for global sea level.

In addition to relatively steady long-term trends, sea levels along the California coast undergo shorter period variability above or below predicted tide levels and long-term trends. Highest sea levels have usually occurred when winter storms and Pacific climate disturbances such as El Niño have coincided with high astronomical tides. So far, there is little evidence that the rate of global sea level rise has accelerated (the rate of rise at California tide gages has actually flattened during the last several years), but climate models suggest strongly that this may change.

Figure 4-6. Observed Change in Sea Level Rise in San Francisco and Projections of Global Mean Sea Level Rise



Source: Cayan et al., in review

Sea level rise, superimposed on predicted tides, weather variations, and El Niño fluctuations, is projected to rise from 4 to 33 inches during the 2000 to 2100 period. This compares to a rate of approximately 7.6 inches (19 cm) per century observed at San Francisco and San Diego during the last 100 years. In addition, the occurrence of extreme events increases as sea level rises.

The number of sea level exceedences modeled for the San Francisco tide gage increases markedly as the mean sea level increases. Thus, historical coastal structure design criteria may be exceeded, the duration of events will increase, and these events will become increasingly frequent as sea level rise continues. On the open coast, impacts during these events will continue to be exacerbated by high surf from wind, waves, and, in the Sacramento/San Joaquin Delta of the San Francisco Bay estuary, by floods that may further jeopardize levees and other structures.

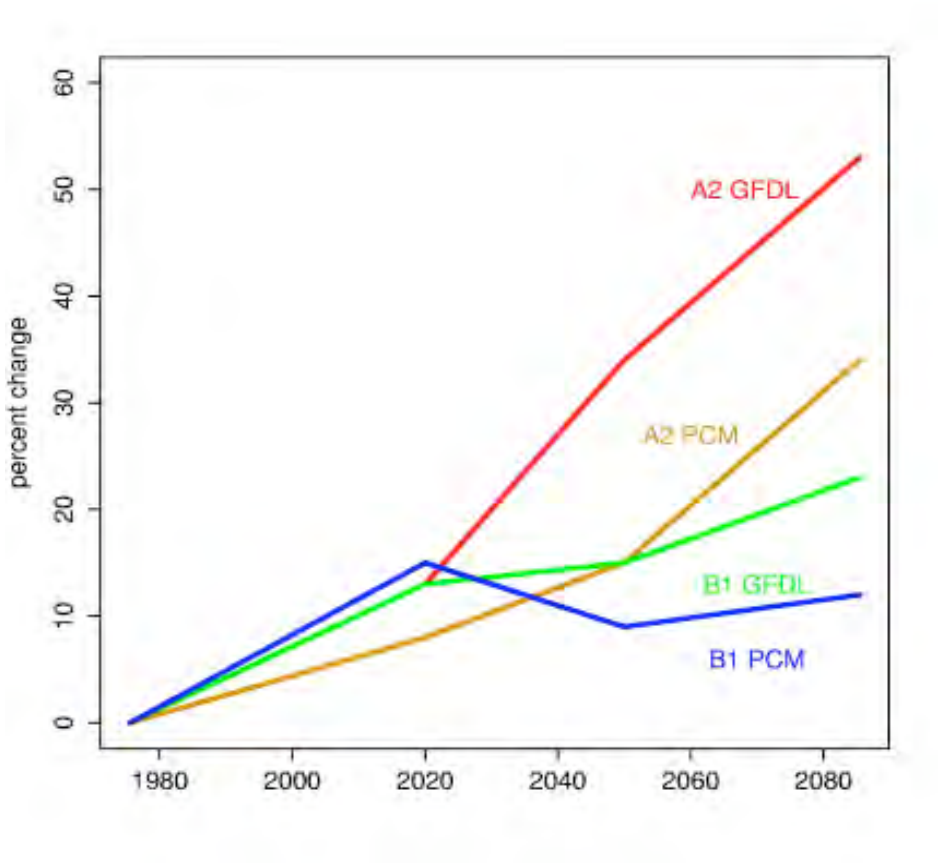
4.6 Forests and Natural Landscapes Impacts16

Climate changes and increased CO_2 concentrations are expected to alter the extent and character of forest and other ecosystems. The distribution of species is expected to shift, the risk of climate-related disturbance such as wildfires, disease, and drought is expected to rise, and forest productivity is projected to increase or decrease depending on species and region. The ecosystems most susceptible to temperature rise are the alpine and sub-alpine forest cover. In addition, changes in fire frequency are expected to contribute to the increase of grasslands, largely at the expense of woodland and shrub-land ecosystems.

Wildfires17

The changing climate may alter the natural fire regimes in ways that could have social, economic and ecological consequences. The most recent analysis, which is a conservative estimate that does not include the effects of extreme fire weather, indicates that wildfire will increase, especially as warming intensifies. These projections suggest that the risk of large wildfires statewide may rise almost 35 percent by mid-century and 55 percent by the end of the century under a medium-high emissions scenario, almost twice that expected under lower emissions scenarios.

Figure 4-7. Percent change in the expected minimum number of large fires per year in California



Source: Westerling et al., in review

These increases in fire season severity could lead to more "bad air" days and increased damage costs of approximately 30 percent above current annual damage costs.

Although society has developed a number of ways to adapt to wildfires, climate change, along with the multiplying impacts of other stresses such as population growth and land-use change, may be pushing California outside of its coping range.

However, in the short-term, California can take actions to improve its ability to live within the state's fire-prone landscapes while maintaining the functioning and structure of the ecosystems upon which its residents depend. These include[18]: 1) the adoption of a risk-based framework for fire management; 2) the reintroduction of fire to fire-prone ecosystems (managing natural fires in some regions rather than suppression). 3) creation of new and flexible policies that are able to differentiate between the diverse ecosystems in California; and 4) a re-evaluation of urban planning and building in the wildland-urban interface.

Pests and Pathogens[19]

Pests and disease have historically had a significant effect on California forests. The changing climate may exacerbate these effects by expanding the range and frequency of pest outbreaks. For example, the introduced pathogen, pine pitch canker (Fusarium subglutinans f. sp. pini), once limited to coastal areas of California, has expanded to the El Dorado National Forest in the Sierra Nevada. Rising winter temperatures in the Sierra Nevada would make conditions more favorable for pitch canker and could result in increased disease severity and economic loss.

Forest Productivity[20]

Several studies have projected increases in forest productivity under future climate change. However, increasing evidence suggests that given the uncertainties concerning how trees will respond to elevated CO_2 concentrations and the increased risk and susceptibility to catastrophic loss, the implications for the forest productivity and the timber industry may be less optimistic.

The most recent assessment of the impact of climate change on the California forest sector used an industry standard planning tool to forecast 30-year tree growth and timber yields for forest stands in El Dorado County under a high and medium temperature scenario.

Conifer tree growth was reduced under all downscaled climate change scenarios. In the medium temperature scenario, productivity in mature stands was reduced by 20 percent by the end of the century. The reductions in yield were more severe (30 percent) for pine plantations. Projections further indicate that the reduced growth rates could lead to substantial decrease in tree survival rates.

4.7 Electricity Sector Impacts[21]

Changes in temperature and other meteorological variables will affect both the generation of and demand for electricity. This section discusses the potential

effects of climate change on hydropower production and electricity demand in California.

Energy Supply—Hydropower

Changes in precipitation levels, should they occur, and patterns and timing of snowmelt would alter the amount of electricity that hydroelectric facilities could generate. It would also affect seasonal availability, with less water available for hydroelectric generation in the late spring and summer months when demand is the highest.

In addition, there is a high likelihood that changes in precipitation and runoff patterns would lead to changes in broader water policies and end-use priorities, such as water supply and flood control, which could place further limitations on hydroelectric production. Currently, hydropower generation contributes about 15 percent of the in-state electricity production, with a range from 9 to 30 percent due to variations in climatic conditions.

Past studies have suggested that annual hydropower generation will increase or decrease with increasing or decreasing precipitation levels in California. The most recent study using an economic-engineering optimization model of the state water system suggests that under a medium temperature scenario, annual generation by the end of this century is expected to decrease by about 30 percent and stream flows are expected to decrease by 28 percent.

Another new study prepared by the Department of Water Resources (DWR) simulating the State Water and Central Valley Projects suggests reductions of approximately 7 percent in hydropower unit electricity generation for most scenarios by mid-century. However, one exception is the low temperature scenario in the less dry model, where electricity generation is projected to increase by approximately 4 percent.

It is important to emphasize that even relatively small changes in in-state hydropower generation result in substantial extra expenditures for energy generation, because losses in this “free” generation must be purchased from other sources.

For example, assuming a decrease of 10 percent from the current average in-state generation level from this renewable energy source, and assuming a price of about 10 cents per kilowatt-hour, this decrease would result in an additional $0.35 billion per year in net expenditures to purchase sufficient electricity to replace the electricity that otherwise would be generated using hydroelectric resources.

Electricity Demand

Electricity demand is projected to rise between 3 to 20 percent by the end of this century. These results are based on correlation functions relating electricity demand with temperatures in key areas in California and future climate projections assuming current socio-economic conditions. In the next 20 years electricity demand would increase from 1 to 3 percent from the baseline, and peak electricity demand would increase at a faster rate.

Since annual expenditures of electricity demand in California represent about $28 billion, even the relatively small increases in energy demand would result in substantial extra energy expenditures for energy services in the state. For example, assuming a linear increase in electricity expenditures from the historical period, a 3 percent increase in electricity demand by 2020 would translate to about $1.2 billion a year in extra electricity expenditures.

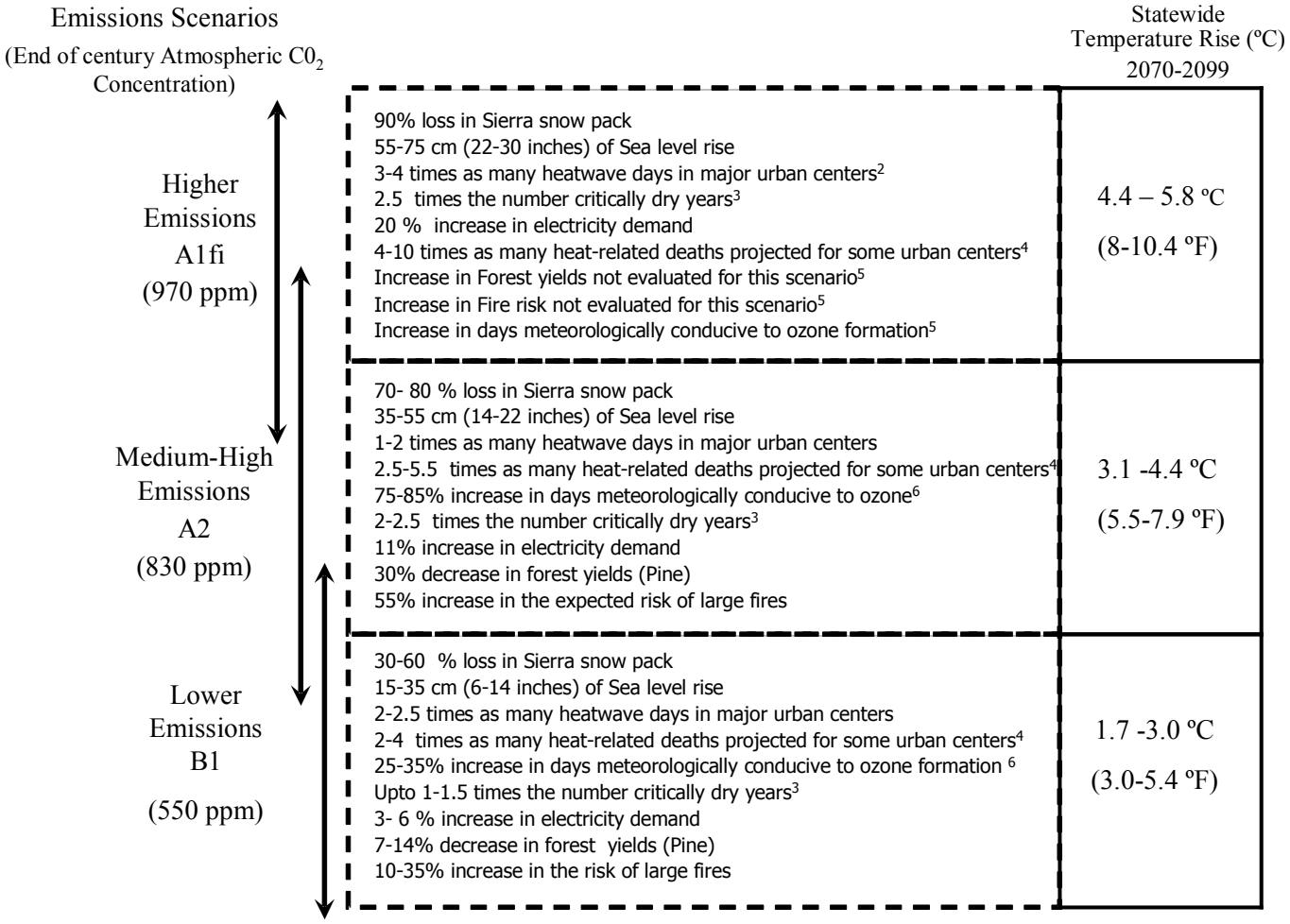
Potential Coping Strategies

There are several options to reduce the negative effect of climate change on the electricity system. The use of modern probabilistic hydrological forecasts for the management of water reservoirs in the state is a promising option being studied. Some options needed to reduce greenhouse gas emissions can be seen as coping strategies. They include, for example, enhanced energy efficiency programs, increased penetration of photovoltaic systems, and the implementation of measures designed to reduce the heat island effect.

4.8 Implications for Mitigation and Adaptation22

Continued climate change would very likely have widespread negative impacts on California's economy, ecosystems, and the health of its citizens. However, the range of possible impacts that are reported in this chapter suggest that following the lower emissions path would likely avoid the most severe impacts projected under the medium and high temperature scenarios.

Figure 4-8. Projected Impacts End of Century



1. Impacts presented relative to 1971–2000.
2. Los Angeles, San Bernardino, San Francisco, Sacramento, and Fresno.
3. Measures for the San Joaquin and Sacramento basins.
4. For Los Angeles, Riverside, and Sacramento.
5. Impacts expected to be more severe as temperatures rise. However, higher temperature scenarios were not assessed for the project.
6. Formation in Los Angeles and the San Joaquin Valley.

However, they also suggest that depending on how sensitive the climate is to rising greenhouse gases, an even lower emissions path might be necessary.

Climate projections show little difference between the emissions scenarios prior to 2035 due to the inertia of the climate system, indicating that even under the lower emissions path some further impacts from climate change are inevitable. Consequently, although it is not the solution to global warming, it is becoming clear that adaptation is an essential complementary strategy to manage some of the projected impacts of climate change. While there are many opportunities for California to increase its capacity to cope with the projected changes, these are often costly.

Furthermore, there are limits to adaptation, especially in addressing the threats of abrupt climate changes or in dealing with those impacts on natural, unmanaged species and ecosystems. These species may not be able to keep up with the increasingly rapid and severe climate change expected in future decades. Finally, the ability to cope and adapt is differentiated across populations, economic sectors, and regions within the state. As a result, without appropriate actions climate change will likely aggravate existing equity issues within California and the rest of the U.S.

For example, the most vulnerable populations to the health impacts of climate change are children, elderly people, and residents of minority and low-income communities—the same groups that already face the greatest health and environmental risks.

The Department of Water Resources and other State agencies have already started to include climate change considerations in their long-range plans. However, no cities in California have a heat emergency action plan; such plans are especially crucial to assist the elderly, especially those living in housing without air conditioning, who may be the most at risk from heat waves.

Thus, the Department of Health Services should develop heat emergency action plans for California (with a focus on protecting the economically disadvantaged) before the need arises. Existing air pollution control programs do not consider the effect of climate change on vulnerable populations; children and the elderly (especially those with pre-existing heart disease) are among the groups most vulnerable to air pollution episodes. Those that live closer to freeways and other emission sources (disproportionately in low-income and minority communities) are exposed to higher levels of pollution.

The Air Resources Board should work with the U.S. Environmental Protection Agency to begin to build climate change considerations into efforts to attain and maintain the health-based air quality standards over the long term.

Better monitoring of California's climate and sensitive climate related sectors will be crucial to detecting and understanding a complex chain of impacts. Finally, the State should continue to generate public discussion and build awareness of the need to manage climate change, develop enabling (or eliminating constraining) adaptation policies, and foster the political will necessary to critically assess and ultimately realize the State's significant adaptive potential.

4.9 Economic Assessment

The projected climatic changes could have significant impacts on California's economy, which is dependent on a number of climate-sensitive industries including tourism, agriculture, and forestry. The California tourism industry, the fifth-largest contributor to the gross state product (GSP), generates annually more than $75 billion for the state economy and supports more than 1 million jobs.23 The economic impact of climate change on California's tourism industry could be significant, especially on those areas dependent on winter and coastal recreation.

The California ski industry, which is rated among the top ski destinations in the country and generates up to $24 million a year, is particularly threatened by the projected loss of snowpack that could force most ski resorts to shut down. California's coastal tourism and recreation sector, which generated an estimated $22 billion dollars for the State in 2000, is also threatened by rising sea levels.

Many of the most severe economic impacts of climate change are likely to be the result of changes in the timing and supply of water during the spring and summer months. This is likely to be exacerbated by increased demand for water (from agriculture and outdoor urban uses) due to increases in temperature. The combined effect of decreased supply and increased demand are likely to have cascading impacts on agricultural production and on electricity demand and supply. Quantifying these impacts is difficult because of the diversity and complexity of the California water system.

Furthermore, the magnitude of the cost depends crucially on the ability of the system to adjust to change. For example, important adjustments may include: developing new crop varieties, improving reservoir operating rules, increasing storage capacity above or below-ground, spreading water marketing, and enhancing water institutions' ability to manage change and uncertainty.

In the electric sector, increases in demand due to a warmer climate could also cost the state. Studies suggest that a 3 percent increase in electricity demand by

2020 would translate to about $1.2 billion dollars a year in extra electricity expenditures.24

Changes in the forestry sector are also likely to negatively affect California's economy. Timber harvests from private lands are a large source of tax revenue for the State. In 2000 the tax revenue from private timber harvest produced $13.1 million state-wide.25 If conifer growth on private forests declines as a result of climate change as projected26, the loss of tax revenue from the Timber Yield Tax is likely to be directly proportional to the decline in growth.

While it is not possible to predict whether technological advances will significantly lower air pollution control costs, climate change could lead to more stringent control beyond current requirements that already cost industry several billion dollars per year. Other costs not yet quantified include those for development of heat emergency action plans for California cities, and possible increases in mosquito and other vector control programs if the climate becomes wetter and warmer.

Many economic costs of climate change may be experienced through the effects of increased frequency and magnitude of weather related hazards, including floods and fires. These can disrupt production in the affected areas and impose significant economic costs both in terms of property damage, lost production, and emergency preparedness and response. The projected increases in wildfires, for example, would require increased investments in suppression infrastructure and damages. Recent analysis suggests increases of approximately 30 percent in projected damage costs by the end of the century27.

The impacts from the potential increase in flooding could also be significant, particularly in the Central Valley locations, where urbanization and restricted channel capacity will pose an increased flooding risk in time, even without climate change. In some locations, the flood control impacts of warming, particularly wetter forms of warming, superimposed on increased exposure from floodplain urbanization, could amount to several billion dollars of costs and damages.28

5 RECOMMENDATIONS FOR EMISSION REDUCTION STRATEGIES

The CAT evaluated a significant number of strategies that could be implemented in California to reduce climate change emissions. The strategies listed in Section 5.2 represent the recommendations of the CAT regarding activities that should

be undertaken in the state. Most of these strategies can be implemented with existing authority of the state agencies represented on the CAT.

5.1 Process for Strategy Selection

As a starting point for emission reduction strategy selection, the CAT relied upon information provided by the Tellus Institute, Center for Clean Air Policy, CEC's Integrated Energy Policy Report, and other existing evaluations of climate change emission reduction policies. The CAT agency representatives then went through a brainstorming exercise and each representative contributed to a larger list of potential emission reduction strategies that either their own agency or other agencies could implement.

The CAT as a whole discussed each strategy and reviewed work plans that included implementation steps, a timeline, and estimated potential emission reductions and costs. From these work plans it was determined which emission reduction strategies could be recommended to the Governor and Legislature at this time and which were either infeasible or would require further analysis.

The CAT then held two public workshops to review the strategies with the public. CAT representatives also met with representatives from low-income and minority communities, environmental organizations, industry representatives, and non-government organizations to review and discuss the list of strategies. Based on comment received at those workshops and meetings, the group made revisions and developed a final list of recommended strategies included in this document.

5.2 Strategies Already Underway

A number of emission reduction strategies are already underway in the state. Table 5-1 lists the strategies underway in California, the agency responsible for implementation, and the climate change emission reduction estimates.

Table 5-1. Emission Reduction Strategies Underway in California

Agency Responsible	Climate Change Emission Reductions[1] (Million Tons CO_2 Equivalent)	
Strategies	2010	2020
Air Resources Board		
Vehicle Climate Change Standards	1	30

Diesel Anti-idling	1	1.2
Public Utilities Commission		
Accelerated Renewable Portfolio Std to33% by 2020 (includes load-serving entities)	5	11
California Solar Initiative	0.4	3
Investor Owned Utility Energy Efficiency Programs(including LSEs)	4	8.8
Integrated Waste Management Board		
Achieve 50% Statewide Recycling Goal	3	3
Energy Commission		
Building Energy Efficiency Standards	1	2
Appliance Energy Efficiency Standards	3	5
Fuel-efficient Replacement Tires & Inflation Programs	1.5	1.5
State and Consumer Services and Cal/EPA		
Green Buildings Initiative	0.5	1.8
Air Resources Board and Cal/EPA		
Hydrogen Highway	Not yet estimated	
Total Potential Emission Reductions	22	67

1 These are approximations that best reflect our current knowledge given a committed and coordinated effort with strong state leadership in partnership with industry.

A summary description of each of the strategies in is included below:

Vehicle Climate Change Standards

With the passage of AB 1493, Pavley, Chapter 200, Statutes of 2002, California moved to the forefront of reducing vehicle climate change emissions. This bill required the state to develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of climate change emissions emitted by passenger vehicles and light duty trucks. Regulations were adopted by the ARB in September 2004.

The ARB analysis of this regulation indicates emissions savings of 1 million tons CO_2 equivalent ($MMtCO_2e$) by 2010 and 30 million tons CO_2 equivalent by

2020.29 This analysis also suggests that operating cost savings will more than offset the incremental costs of improved technologies, resulting in consumer savings of $5 billion annually by 2020.

Diesel Anti-Idling

Reduced idling times and the electrification of truck stops can reduce diesel use in trucks by about 4 percent, with major air quality benefits. In July 2004 the ARB adopted a measure to limit diesel-fueled commercial motor vehicle idling.30 ARB analysis indicates that anti-idling measures could reduce climate change emissions by 1.2 MMtCO2e in 2020.31 ARB also estimates that the proposed measures would provide savings of up to $575 million (NPV through 2013) to California businesses as a result of fuel savings and reduced engine maintenance costs.

Accelerated Renewable Portfolio Standard (33 percent by 2020)

The Governor has set a goal of achieving 33 percent renewables in the State's resource mix by 2020. The joint PUC/Energy Commission September 2005 Energy Action Plan II (EAP II) adopts the 33 percent goal. The PUC and Energy Commission have already commenced review of the legal, regulatory, and infrastructure changes necessary to achieve the Governor's goal.

The Center for Resource Solutions has prepared a preliminary report for the CPUC entitled *Achieving a 33% Renewable Energy Target* (The Center for Resource Solutions, November 1, 2005), which concludes that the 33 percent target by 2020 is achievable and discusses the major hurdles and necessary implementation steps. The report is a starting point for further review by the CPUC on instituting a 33 percent goal.

California Solar Initiative

The solar initiative includes installation of 1 million solar roofs or an equivalent 3,000 MW by 2017 on homes and businesses, increased use of solar thermal systems to offset the increasing demand for natural gas, use of advanced metering in solar applications, and creation of a funding source that can provide rebates over 10 years through a declining incentive schedule.

Legislation to codify the Governor's initiative (SB 1) failed to pass the California Assembly in the fall of 2005. However, the PUC, in cooperation with the Energy Commission and the Governor's Office, will implement the California Solar Initiative under its existing statutory authority.

Investor-Owned Utility Energy Efficiency Programs

In September 2004, the PUC adopted aggressive savings targets for the investor-owned utility energy efficiency programs through 2013. The savings targets through 2013 are challenging goals to meet, and the PUC will reassess these targets and adopt more realistic goals during each three-year program cycle.

The PUC funds energy efficiency programs through the Public Goods Charge and the resource procurement budgets of the utilities. For the 2006–2008 program cycle, the total energy efficiency budget for all of the investor-owned utilities is approximately $2 billion, for a total projected annual net savings of 7,371 gigawatt hours and 121,989 million therms. These projections exceed the savings targets by 108 percent and 109 percent respectively. By 2008 these programs will reduce annual carbon dioxide emissions by more than 3 million tons per year.

Achieve 50 percent Statewide Recycling Goal

Achieving the State's 50 percent waste diversion mandate as established by the Integrated Waste Management Act of 1989, (AB 939, Sher, Chapter 1095, Statutes of 1989), will reduce climate change emissions associated with energy intensive material extraction and production as well as methane emission from landfills. Currently a diversion rate of 48 percent has been achieved on a statewide basis. This strategy would result in achieving an additional 2% waste diversion of recyclables from landfills using existing authorities and mandates, collection infrastructures, and recycling processes.

Building Energy Efficiency Standards

Public Resources Code 25402 authorizes the Energy Commission to adopt and periodically update its building energy efficiency standards (that apply to newly constructed buildings and additions to and alterations to existing buildings). The Energy Commission updates the standards at its discretion (i.e. three-year cycle for building standards). In addition to the long existing legislative mandates, recent policies have placed priority on and established specific goals for updating of the standards.

The Energy Action Plan and the Integrated Energy Policy Report both call for ongoing updating of the standards, including meeting energy efficiency goals, addressing demand response and promoting the combination of solar photovoltaics and high-energy efficiency buildings. The Energy Commission has also initiated work for the building standards that will go into effect in 2008 (i.e. the first of three update cycles that will occur prior to 2015).

Appliance Energy Efficiency Standards

Public Resources Code 25402 authorizes the Energy Commission to adopt and periodically update its appliance energy efficiency standards (that apply to devices and equipment using energy that are sold or offered for sale in California). The Energy Commission updates the standards at its discretion. In addition to the long existing legislative mandates, recent policies have placed priority on and established specific goals for updating of the standards.

New standards for a variety of appliances were adopted in December 2004. Some standards under consideration in December were delayed to further consider manufacturer comments. Those standards are being developed by the Energy Commission at the present time. The estimates in represent the expectation of full adoption of these standards.

Fuel-efficient Replacement Tires & Inflation Programs

State legislation (Chapter 912, Statutes of 2001) directed the Energy Commission to investigate and to recommend ways to improve fuel efficiency of vehicle tires. The bill established a statewide program to encourage the production and use of more fuel efficient tires, and required the Energy Commission to:

Establish a test procedure for measuring tire fuel efficiency.

Develop a database on the fuel efficiency of existing tires in order to establish an accurate baseline of tire efficiency.

Develop a rating system for tires that provides consumers with information on the fuel efficiency of individual tire models.

Develop a consumer-friendly system to disseminate tire fuel-efficiency information as broadly as possible.

Study the safety implications of different policies to promote fuel efficient replacement tires in the consumer market.

Evaluate a mandatory fuel efficiency standard for all after-market tires sold in California.

Develop consumer incentive programs that would offer a rebate to purchasers of replacement tires that are more fuel-efficient than the average replacement tire.

Study ways to improve the fuel-efficiency of vehicles in the State's fleet.

AB 844 later required tire manufacturers to report to the Energy Commission the rolling resistance and relative fuel economy of replacement tires sold in California.

Green Buildings Initiative

Governor Schwarzenegger's Green Building Executive Order, S-20-04, sets an ambitious goal of reducing energy use in public and private buildings by 20 percent by the year 2015, as compared with 2003 levels. The Executive Order and related action plan spell out specific actions state agencies are to take with state-owned and -leased buildings. The order and plan also discuss various strategies and incentives to encourage private building owners and operators to achieve the 20 percent target.

Preliminary estimates indicate that 6.5 million tons of CO_2 will be reduced annually by the year 2015 through building efficiency efforts in commercial and institutional buildings. This number is based on the average displaced power generation being an efficient natural gas combined cycle turbine. The 6.5 million-ton estimate has been adjusted in to ensure against double counting amongst other strategies being recommended by the CAT.

Hydrogen Highway

The California Hydrogen Highway Network (CA H2 Net) is a State initiative to promote the use of hydrogen as a means of diversifying the sources of transportation energy in order achieve a secure energy future, address environmental, public health, and economic challenges, and work in partnership with other State programs to advance energy efficiency and renewable energy. The CA H2 Net mission is to assure that hydrogen infrastructure is in place as fuel cells and other hydrogen technologies reach commercial readiness.

Hydrogen can be derived from a variety of sources including petroleum based feedstock to a range of renewable resources. To assure that the production of hydrogen and operation of hydrogen fueled vehicles is environmentally beneficial the CA H2 Net has the clearly defined goals of utilizing at least 20 percent renewable resources in the production of hydrogen, reducing greenhouse gas emissions by at lease 30 percent, and to not increase smog forming and toxic pollutants relative to fossil fuel vehicle use.

5.3 Strategies Needed to Meet California's Targets

Table 5-2 is a list of strategies that the Climate Action Team recommends be pursued in the next two years. Many of these strategies are currently partially

underway and most can be implemented with current authority; most do not require legislation to implement. Implementation of these strategies will provide significant emission reductions. A summary description of each of the strategies in Table 5-2 is included below:

Table 5-1. Strategies Needed to Meet California's Targets

Agency Responsible	Start Date	Climate Change Emission Reductions (Million Tons CO_2 Equivalent)[1]	
Air Resources Board		2010	2020
Other New Light Duty Vehicle Technology Improvements	2006	0	6
HFC Reduction Strategies	2006	2.7	8.5
Transport refrigeration units, Off-road electrification, Port electrification (ship to shore)	2006	<1	<1
Manure Management	2006	1	1
Semi Conductor Industry Targets (PFC Emissions)	2006	2	2
Alternative Fuels: Biodiesel Blends	2006	<1	<1
Alternative Fuels: Ethanol	2006	<1	3.2
Heavy Duty Vehicle Emission Reduction Measures	2006	0	3
Reduced Venting and Leaks in Oil and Gas Systems	2006	1	1
Public Utilities Commission			
Investor-Owned Utility (IOU) Additional Energy Efficiency Programs/Demand Response	2013	NA	6.3
IOU Combined Heat and Power Initiative	2006	1.1	4.4
IOU Electricity Sector Carbon Policy	2006	1.6	2.7
Integrated Waste Management Board			
Landfill Methane Capture	2006	2	3
Zero Waste—High Recycling	2006		3

Resources Agency			
Forest Management	2006	1-2	2-4
Forest Conservation	2006	4.2	8.4
Fuels Management/Biomass	2006	3.4	6.8
Urban Forestry	2006	0	3.5
Afforestation/Reforestation	2006	0	12.5
Water Use Efficiency	2008	0.4	1.2
Energy Commission			
Building Energy Efficiency Standards	2005	TBD	TBD
Appliance Energy Efficiency Standards	2006	TBD	TBD
Cement Manufacturing	2006	<1	<1
Municipal Utility Energy Efficiency Programs/ Demand Response	2006	1	5.9
Municipal Utility Renewable Portfolio Standard	2006	<1	3.2
Municipal Utility Combined Heat and Power	2006	0	<1
Municipal Utility Electricity Sector Carbon Policy	2006	3	9
Alternative Fuels: Non-Petroleum Fuels	2006	TBD	TBD
State and Consumer Services/CalEPA			
Transportation Policy Implementation	Still Being Considered		
Business, Transportation & Housing			
Measures to Improve Transportation Energy Efficiency	2006	1.8	9
Smart Land Use and Intelligent Transportation	2006	5.5	18
Department of Food & Agriculture			
Conservation tillage/cover crops	2006	TBD	TBD
Enteric Fermentation	2006	<1	<1
		35-	115-

Total Potential Emission Reductions	40	120

[1] These estimates are based on best available current information and will be updated as needed.

Other New Light Duty Vehicle Technology Improvements

In September 2004 the California Air Resources Board approved regulations to reduce climate change emissions from new motor vehicles. The regulations apply to new passenger vehicles and light duty trucks beginning with the 2009 model year. The standards adopted by the Board phase in during the 2009 through 2016 model years. When fully phased in, the near term (2009–2012) standards will result in about a 22 percent reduction as compared to the 2002 fleet, and the mid-term (2013–2016) standards will result in about a 30 percent reduction.

New standards would be adopted to phase in beginning in the 2017 model year (following up on the existing mid-term standards that reach maximum stringency in 2016). Assuming that the new standards call for about a 50 percent reduction, phased in beginning in 2017, this measure would achieve about a 4 MMT reduction in 2020. The reduction achieved by this measure would significantly increase in subsequent years as clean new vehicles replace older vehicles in the fleet—staff estimates a 2030 reduction of about 27 MMT.

Hydrofluorocarbon Reduction Strategies

ARB staff has identified five possible measures to reduce HFC emissions from vehicular and commercial refrigeration systems:

1. *Ban the retail sale of hydrofluorocarbon* (*HFC) in small (mostly 12-oz.) cans*. This would end the loss of can “heels” (small amounts of HFCs remaining in the can after service is complete) and prevent do-it-yourself re-filling of vehicular air conditioning systems.

2. *Require that only low-GWP refrigerants be used in new vehicular systems*. For vehicles subject to the ARB motor vehicle climate change emission reduction regulations, this requirement would take effect in 2017 because the adopted regulations already specify standards and compliance options through 2016. For medium- and heavy-duty vehicles not subject to the AB 1493 regulation, the requirement would take effect in the 2010 timeframe.

3. *Adopt specifications for new commercial refrigeration*. Limit the global warming potential of refrigerants used in refrigerators in retail food stores, restaurants, and refrigerated transport vehicles (trucks and railcars) and/or

require that centralized systems with large refrigerant charges and long distribution lines be avoided in favor of systems that use much less refrigerant and lack long distribution lines.

4. Add refrigerant leak-tightness to the “pass” criteria for vehicular Inspection and Maintenance programs (all vehicles) and adopt an “inspect and repair” measure for commercial systems. Require that systems either be leak-free at smog-check or be empty and inoperable.

5. *Enforce the federal ban on releasing HFCs.* This measure would focus on reducing emissions during the servicing and dismantling of vehicular air conditioners and commercial refrigeration systems.

Transportation Refrigeration Units, Off-road Electrification, Port Electrification (ship to shore)

Transportation Refrigeration Units

Require all new transportation refrigeration units (TRU) to be equipped with electric standby.

Require cold storage facilities to install electric infrastructure to support electric standby TRUs.

The technologies to be employed in this measure include electric standby for TRUs and electric infrastructure at cold storage facilities.

Emission reduction estimates are about 0.14 MMT in 2020 assuming 50 percent electrification and TRU operation at a facility of about 30 percent.

Off-road Electrification

Off-road electrification would likely be achieved using a combination of regulatory and incentive approaches. ARB could conduct outreach to encourage replacement of diesel engines with electric motors to take advantage of the incentive rate structure and Moyer funding, and to comply with District and pending ARB regulations.

The in-use stationary diesel agricultural engine regulation currently under development at ARB will propose emission performance standards for engines rather than mandate electrification or any other specific technology. Staff believes that most engines will be replaced with new cleaner certified diesel engines or with electric motors. Retrofit and alternative fuels are other potential means of compliance.

Port Electrification

ARB would require phase-in of vessel modifications and infrastructure to support expanded use of shore-side power.

Technologies to be employed in this measure include vessel modifications and shore-side infrastructure.

Shore-side power could be used in 2 to 5 percent of ship visits in 2010 and 20 to 25 percent of ship visits in 2020. The reductions in CO_2 emissions are calculated as the difference between the CO_2 emissions resulting from the generation of shore-side power supplied by utility companies and the CO_2 emissions resulting from power generated by shipboard diesel generators.

2010

Goal: 5 percent of ship visits use shore-side power

Estimated CO_2 reduction: 0.016 MMT

2020

Goal: 25 percent of ship visits use shore-side power

Estimated CO_2 reductions: 0.18 MMT

Manure Management

Proposed San Joaquin Valley Rule 4570, Confined Animal Facilities, is intended to reduce volatile organic compounds (VOC) from confined animal facilities and is in the initial stages of development. Some general concepts that may appear in the rule include: (1) different requirements based on facility size; (2) specific control requirements included on a list of technologies; (3) a mix of control options selected from a list; and (4) a facility-wide control efficiency that will achieve a certain percentage reduction. Possible control options include management practices, manure handling practices, and lagoon/liquid waste control options.

Emission reduction estimates of approximately 1 million tons (MMT) could be achieved through the use of biogas digesters along with the production of electricity and/or heating applications. ARB estimates of climate change emission reductions through implementation of anaerobic digesters have yet to be determined.

Semi Conductor Industry Targets (PFC Emissions)

ARB could help target climate change emission reductions through development of a model rule to be considered for adoption by the districts. Based on the

voluntary target outlined in the Memorandum of Understanding between the U.S. EPA and the Semiconductor Industry Association, emission reduction estimates of approximately 2 MMT for semiconductor operations in both 2010 and 2020 are possible.

Alternative Fuels: Biodiesel Blends

ARB would develop regulations to require the use of 1 to 4 percent biodiesel displacement of California diesel fuel. A climate change emission reduction of about 0.4 MMT would be achieved in 2010 based on 2 percent displacement of diesel fuel. ARB and CEC staff estimate that biodiesel could likely provide up to a 4 percent displacement of diesel fuel by 2020. This would provide about 0.8 MMT of greenhouse gas reductions. It is important to note, however, that current supplies of biodiesel are limited in California. Thus this strategy presumes significant market expansion in addition to regulatory steps.

Alternative Fuels: Ethanol

More than 200,000 flexible fueled vehicles are present in California today that could use E-85 without any equipment modifications. This number will increase as manufacturers continue to produce additional new cars that are E-85 compatible. If E-85 became widely available at prices competitive with gasoline, a significant portion of the fleet could be fueled primarily with ethanol by 2015.

The percentage of ethanol used in gasoline could be increased to the maximum 10 percent (E-10) that is compatible with current vehicles. (The current gasoline supply contains 5.7 percent ethanol). However, significant permeation emissions caused by low percentage ethanol blends used in the summertime suggest that low percentage blends are best limited to wintertime use. In addition, other fuel properties may need to be adjusted to ensure that the use of E-10 does not increase emissions of smog forming compounds.

If ethanol used in California continues to be derived from corn or other similar grains, the climate change emission benefits due to increased use of E-85 would be negligible in 2010 and 2.7 MMT in 2020 (assumes that about 10 percent of the entire light duty vehicle fleet uses E-85 regularly.) Use of ethanol derived from biomass or waste material would more than double the climate change emission reduction benefit.

Using 10 percent ethanol content in gasoline during the wintertime (six months) would result in ethanol use roughly equivalent to the level required under the recently adopted federal energy bill, and thus produce no additional climate change emission reduction benefits.

Heavy-Duty Vehicle Emission Reduction Measures

Climate change emissions can be reduced with improved aerodynamics, climate engine-based improved efficiency, vehicle weight reduction, and rolling and inertia resistance improvements. ARB has also identified other possible measures, such as an education program for the heavy duty vehicle sector as well as the light and medium duty vehicle sectors that would educate drivers as to how to optimize vehicle operation.

Emission reduction estimates of about 0.2 MMT for 2010 and about 3 MMT for 2020 were derived assuming an efficiency improvement of 65 percent from 1990 levels is possible by 2030. These estimates were based on ARB/CEC estimates of fleet-wide diesel-use reductions achievable under a national approach based on DOE's 21st Century Truck Program.

Reduced Venting and Leaks in Oil and Gas Systems

A model rule would be developed to be considered for adoption by the Air Pollution Control Districts. This measure involves improved management practices and does not rely on the application of new technology.

Estimated potential climate change emission reductions of 1 MMt CO_2 equivalent were derived assuming reduced leak and venting in the production, processing, transport, and distribution of oil and natural gas in 2010 and 2020. This goal is based on U.S.EPA estimates that approximately 33 percent of emissions from oil and gas systems can be avoided cost-effectively32.

Investor Owned Utility Additional Energy Efficiency Programs/Demand Response

In September 2004, the PUC adopted aggressive savings targets for the IOUs' energy efficiency programs through 2013. The savings targets through 2013 are stretch goals and the PUC will reassess these targets and adopt the actual goals during each three-year program cycle. The PUC funds energy efficiency programs through the Public Goods Charge and the IOUs' resource procurement budgets. For the 2006–2008 program cycle, the total energy efficiency budget for all of the IOUs is approximately $2 billion, for a total projected annual net savings of 7,371 gigawatt hours and 121,989 million therms. These projections exceed the savings targets by 108 percent and 109 percent respectively. By 2008 these programs will reduce annual carbon dioxide emissions by more than 3 million tons per year.

Over the next year, the PUC will develop a risk/reward incentive mechanism for the IOUs and refine energy measurement and verification protocols. In 2008, the

PUC will evaluate and adopt the 2009–2011 energy efficiency savings goals and programs of the IOUs.

Investor-Owned Utility Combined Heat and Power Initiative

This strategy encourages the installation of on-site power production to meet both heat and electricity loads, known as combined heat and power projects (CHP). The PUC's existing Self-Generation Incentive Program allocates $0.80 per watt to eligible CHP projects in the territories of the IOUs, up to a capacity size of 5 MW. Currently, all SGIP funds are reserved through 2007, although funding may become available if proposed projects do not materialize.

This strategy would seek to develop additional programs to further encourage the development of CHP. These additional programs are not yet underway, will require further consideration, and could likely require administrative, legislative, regulatory, and budget initiatives. To effectively implement this strategy, it is likely various policy instruments will be needed to attain the realistic market potential and subsequent CO_2 reductions.

These policy mechanisms may include regulatory incentives to encourage IOUs to promote customer and utility-owned CHP, changes to IOU rate design, market rules and regulations enabling easier access to wholesale markets, production tax credits for CHP, and other measures or incentives directed at key commercial and industrial activities in California. Legislation is required in order to apply a similar strategy for CHP programs implemented by publicly-owned utilities.

Investor Owned Utility Electricity Sector Carbon Policy

The PUC is currently investigating various strategies and incentives to encourage the IOUs to make cost-effective procurement decisions that are based in part on reducing climate change emissions. These strategies include emissions targets or caps, incentives for preferred procurement options, and incentives for portfolio optimization and total cost minimization.

The PUC conducted workshops in March 2005 on the procurement incentive framework and issued a staff report in March 2005. The post-workshop comments were filed in April and May 2005. A final decision on whether to include a carbon cap in the procurement incentive framework will likely be adopted by the beginning of 2006. This strategy includes the following steps:

Determine a methodology the IOUs will use to report their climate change emissions.

Continue to work with the CEC to ensure that the IOUs and the municipal utilities use consistent methodologies to report their emissions.

Begin work to establish emission baselines for IOUs.

The emission reduction potential for this strategy assumes that 20 percent of California's power is generated by coal-fired power plants.

Landfill Methane Capture

Methane production varies greatly from landfill to landfill depending on site-specific characteristics such as the quantity of waste in place, waste composition, moisture content, landfill design and operating practices, and climate. Unless captured first by a gas recovery system, methane generated by the landfill is emitted when it migrates through the landfill cover to the atmosphere and becomes a potent climate change emission.

Landfills can install direct gas use projects or electricity projects with backup flare systems to capture and use methane. The technical applicability of any mitigation option is dependent on the amount of landfill gas generated by landfills in a given size category.

Zero Waste—High Recycling

Additional recovery of recyclable materials from landfills will reduce the climate change emissions associated with energy intensive material extraction and production as well as methane emission from landfills. Transforming organics/biomass and plastic waste into marketable products will also reduce the amount of material going to landfill, and therefore will further reduce climate change emissions. Currently, the State is mandated to divert 50 percent of waste going to landfills as established by the Integrated Waste Management Act of 1989. Efforts to exceed the 50 percent goal would allow for additional reductions in climate change emissions.

Forest Management

Strategies for storing more carbon through forest management activities can involve a range of management activities such as increasing either the growth of individual trees, the overall age of trees prior to harvest, or dedicating land to older aged trees. With roughly 4 million acres of private managed forestland in California, changes in forest management can produce significant amounts of greenhouse gas benefits for the state.

Inclusion of the forest sector in climate mitigation policy can lead to additional local environmental benefits that may help the state's resources adapt to potential negative effects of climate change. Overall changes in forest management can enhance and protect biodiversity, water quality, and habitat resources that the state will increasingly seek to protect in the advent of climate change.

Forest management projects could be included in a broader multi-sector greenhouse gas "cap and trade" or climate trust system. In a cap and trade program, forest management projects could provide offsets that would be purchased by capped entities. In a climate trust program, the state would fund forest management projects and recapture the costs by selling carbon credits to industries needing to reduce their climate change emissions.

The regulatory framework for timber harvesting requires landowners to secure permits from a large number of agencies to meet the requirements of the Forest Practice Act, Endangered Species Act, and Clean Water Act. Together the time and cost of obtaining these permits have led to conversions of timberlands to other uses and made it more difficult and time consuming to implement forest management activities that would increase carbon storage. Simplification of the permitting processes for forest management and timber harvesting would result in additional carbon being stored over a larger number of acres.

Forest Conservation

Conservation projects are designed to minimize/prevent the climate change emissions that are associated with the conversion of forestland to non-forest uses by adding incentives to maintain an undeveloped forest landscape.

California is losing forestland at increasing rates: 35,000 to 40,000 acres of private forestland is converted annually to non-forest uses (Bill Stewart, 2005), which could contribute as much as 12 million tons of CO_2 emissions annually. Policies designed to minimize or prevent forestland conversion to non-forest uses could provide significant benefits by 1) preventing or minimizing climate change emissions that are associated with increasing forestland conversion in California and 2) maintaining the opportunity to increase forest carbon stocks on these lands through additional sequestration over time.

Forest conservation can also enhance and protect biodiversity, water quality, and habitat resources that the state will increasingly seek to protect from the negative effects of climate change. Finally, in contrast to the other forest sector strategies such as reforestation, the climate benefits of forest conservation are immediate.

Specific actions that can be taken include establishing a state forest conservation program that operates independently from the federal Forest Legacy program; increasing Forest Legacy Program Funding with an $11 million annual investment that could prevent the conversion of 14,000 acres of forestland. Another step could include directing the Wildlife Conservation Board, the State Conservancies, and other state land acquisition and easement programs to consider climate benefits in evaluating and ranking projects to be funded. Finally, the state could include forestland conservation as an emission reduction project in a broader multi-sector greenhouse gas cap and trade or climate trust system.

Fuels Management/Biomass

Large, episodic, unnaturally hot fires are an increasing trend on California's wild lands because of decades of fire suppression activities, sustained drought, and increasing insect, disease, and invasive plant infestations. Actions taken to reduce wildfire severity through fuel reduction and biomass development would reduce climate change emissions from wildfire, increase carbon sequestration, replace fossil fuels, and provide significant local economic development opportunities.

Fire management and biomass development projects could be accelerated by establishing a new state goal of thinning, removing, and treating 212,000 acres of public and privately owned forestland annually by 2010, and 275,000 acres by 2020. Such projects would: 1) reduce the intensity of wildfires and their associated greenhouse gas emissions; 2) increase the carbon stock of the remaining trees, 3) remove pests that create mortality of live stored carbon and reduce large damaging wildfires, 4) reduce state and local fire suppression costs; 5) provide a source of renewable alternative fuel; and 6) provide significant rural economic development opportunities.

Urban Forestry

This strategy would expand the State Urban Forestry Program. A new state-wide goal of planting 5 million trees in urban areas by 2020 would be achieved through the expansion of local urban forestry programs. At a cost of $100 per tree, $500 million would have to be invested by local urban forestry programs to meet this target.

This could be achieved by issuing an Executive Order to establish a new state-wide goal and directing the Board of Forestry and California Department of Forestry to launch an aggressive public assistance and outreach campaign to

expand local urban forestry programs. The state could request that the California Climate Action Registry develop and adopt a protocol for the certification of climate change emission reductions from local urban forestry programs.

This strategy would develop new urban biomass programs. The California Department of Forestry would develop an urban biomass utilization program to provide technical advice, planning, education, and seed money for local government marketing centers for biomass waste.

Afforestation (Planting Trees)/Reforestation Projects

Reforestation projects focus on restoring native tree cover on lands that were previously forested and are now covered with other vegetative types. Recent studies have estimated that approximately 9 million acres of land in California could be reforested to increase carbon stocks and provide other benefits. Each of these acres has the potential to store between 150 to 230 tons of carbon.

Specific actions that could be taken include: establishing a new statewide goal of reforesting 500,000 acres of forestlands by 2020, including 250,000 acres on private lands and 250,000 acres on federal lands; seeking $30 million annually, or $300 million in bond funds to meet these targets; establishing a long-term loan program to fund private land reforestation; establishing a multisector cap and trade program where reforestation projects can be included as offsets in a broader, mulit-sector greenhouse gas cap and trade program; and establishing a state-owned carbon bank, modeled after Oregon's Climate Trust, as part of a cap and trade program.

Water Use Efficiency

Approximately 19 percent of all electricity, 30 percent of all natural gas, and 88 million gallons of diesel are used to convey, treat, distribute and use water and wastewater. The California Energy Commission (CEC) estimates 44 million tons of CO2 emissions are expelled annually on average to provide the 44 million acre feet (MAF) of water used statewide.

The key to the reduction of climate change emissions through water use efficiency is strategic investment in measures tied to water energy intensity. When a unit of water is saved, so too is the energy required to convey, treat, affect local delivery, perform wastewater treatment and safely dispose of that unit of water. In short, saving water saves energy. Saving water that gets treated as wastewater saves more energy. Saving water that gets heated or additionally pressurized saves still more.

Region, elevation, water use sector, and energy source, among other factors, all influence water energy intensity. The statewide average for climate change emissions per acre foot is skewed by the wide local variation in the water energy intensity. Everything else being equal, a cooling tower condition meter installed in an industrial plant in Northern California will save 2,920 kWh compared to 9,270 kWh saved annually in a comparable plant south of the Tehachapi Mountains.

Increased water use efficiency is the key element in the California Water Plan Update (Bulletin 160-05) plans to meet the state's needs for water in 2030 with a growing population. The plan calls for reducing urban water use by 1.1 to 2.3 MAF per year and agricultural water use by 0.5 to 2.0 MAF per year by 2030. Accelerating the investment to attain that water use savings by 2015 would result in an estimated additional climate change emission reductions of approximately 30 million tons cumulatively by 2030. Accelerating the investment to 2010 would result in a further cumulative reduction of 10 million tons.

The California Bay-Delta Authority's larger estimated potential for 3.0 MAF per year urban water use reduction requires a greater rate of local and state/federal investment in conservation. Incentive driven advances in water-saving technology over the next 25 years potentially could further push savings beyond the levels indicated.

A comprehensive program focused on the state's water and wastewater agencies and their customers would yield significant benefits to the state including: meeting the state's water plan, increasing energy system reliability and price stability, meeting the state's renewable portfolio standard goals and reducing the state's greenhouse gas emissions. Following are measures to include in this comprehensive program:

Accelerate investment in water use efficiency: Accelerate implementation of best management practices and efficient water management practices (EWMP) and incentives. Coordinate this accelerated investment with the state's investments in energy efficiency. Start in the areas of the state with most energy-intensive water use cycles.

Increase the energy efficiency of all water and wastewater treatment operations. Develop long-term programs to better mesh with the long-term investments in water and wastewater infrastructure.

Improve price signals so that water-related energy use can be shifted off periods of peak energy demand.

Increase water storage to increase operational flexibility throughout the water use cycle and reduce peak electric system energy requirements.

Identify suitable locations for new pumped storage facilities. Construct facilities at these locations.

Increase energy production by water and wastewater agencies from renewable sources such as in-conduit hydropower and biogas. Add generation from solar and wind resources.

Building Energy Efficiency Standards

As part of the process of updating the Building Energy Efficiency Standards, the Energy Commission evaluates new and emerging technology for possible inclusion in the standards. The CEC administers an ongoing "compliance option" process which evaluates to what extent compliance credit should be approved for new technologies and develops algorithms that can be used to properly evaluate their energy consequence within building simulation computer programs that are used for standards compliance.

Upon commission approval, compliance options can be used to demonstrate compliance with the performance approach in the standards. Once a compliance option has been in existence for a period of time, the commission often considers whether or not the compliance option should be made a requirement of the standards (as a prescriptive requirement and basis of the energy budget established for the performance standards).

Appliance Energy Efficiency Standards

As part of the process of updating the Appliance Energy Efficiency Standards, the CEC evaluates new and emerging technology for increasing the energy efficiency of appliances and equipment for possible inclusion in the standards. The Commission’s Buildings and Appliances Office works on an ongoing basis with the Public Interest Energy Research (PIER) program and with the Utility Codes and Standards Programs to track promising new technologies and consider their appropriate inclusion in the standards.

Fundamentally, the standards updating process is achieved thorough technology assessment of the potential to include new technologies in the standards, and the program is continuously evaluating new technologies.

Cement Manufacturing

This strategy involves cost-effective reductions to reduce energy consumption and to lower carbon dioxide emissions in the cement industry. There is a large technical potential to improve energy efficiency in cement operations at a reasonable cost.

Climate change emissions from burning fossil fuels in the manufacturing of cement produces 1.5 to 2.0 percent of U.S. carbon dioxide emissions. Roughly half is from fossil fuel combustion and roughly half is from the conversion of limestone (45 million metric tons per year). California's cement industry produced 5.6 million metric tons in 2001; total statewide greenhouse gases approached 500 million metric tons in 2001.

Annual emissions from the manufacturing of cement are growing at a rate of 2 percent per year, according to industry sources and using California-specific data. Direct emissions of carbon dioxide are estimated to rise from 10.4 million metric tons in 2005 to more than 15 million metric tons in 2025. Use of limestone Portland cement and the use of blended cement account for 70 percent of the potential emission reductions and would cost less than $10 per metric ton.

State policy options can take several forms, including technology mandates, financial incentives, negotiated agreements, voluntary commitments, emissions-intensity benchmarking, or mandatory measures. Policy changes would be needed to encourage the use of limestone and blended cement and to allow waste tires to be used as a fuel in cement manufacturing. Based on CEC's analysis, these measures have been shown to provide cost-effective climate change emission reduction benefits.

Municipal Utility Energy Efficiency Programs

The Energy Commission and the California PUC are collaborating on additional energy efficiency programs beyond those programs already adopted.

While the Energy Commission does not have regulatory authority over the publicly owned utilities in the way that the CPUC regulates the IOUs, the publicly owned utilities are required to report their energy savings to the CEC. A process to ensure comparability between public benefit program savings and funding data reported by public and investor-owned utilities will need to be established. Possible steps for implementing this strategy include:

Pursuing a cooperative agreement with the publicly owned utilities to achieve the needed CO_2 reductions.

Establishing a formal memorandum of understanding (MOU) with the utilities to achieve these targets.

Seeking state legislation requiring the publicly owned utilities to contribute proportionally to the State's energy efficiency goals.

Municipal Utility Renewable Portfolio Standard

California's Renewable Portfolio Standard (RPS), established in 2002, requires that all load serving entities achieve a goal of 20 percent of retail electricity sales from renewable energy sources by 2017, within certain cost constraints. The *2003 Energy Action Plan* and the *2003 Integrated Energy Policy Report* (2003 *Energy Report*) accelerated the 20 percent goal from 2017 to 2010. The *2004 Energy Report Update* further recommended an increased goal of 33 percent renewable by 2020, which the California Public Utilities Commission (CPUC) and the California Energy Commission (Energy Commission) adopted in the *2005 Energy Action Plan II*.

The Energy Commission and the CPUC are responsible for implementing the RPS for the investor-owned utilities, electric service providers, and community choice aggregators. The publicly owned utilities are responsible for implementing their own RPS programs.

The CPUC has undertaken a study to identify the steps necessary to achieve the 33 percent goal for the state's IOUs. The Energy Commission is undertaking a similar related study on RPS programs adopted by publicly owned utilities, including barriers and policy options to accelerate those programs to reach the 20 percent goal by 2010 and 33 percent goal by 2020. Possible steps for implementing this strategy include:

Pursuing a cooperative agreement with the publicly owned utilities to achieve the needed climate change emission reductions.

Seeking state legislation requiring the publicly owned utilities to contribute proportionally to the state's RPS goals.

Municipal Utility Combined Heat and Power

This strategy constitutes cost-effective reductions from fossil fuel consumption in the commercial and industrial sector through application of on-site power production to meet both heat and electricity loads. To effectively implement this strategy, various policy instruments will likely be needed to attain the realistic market potential and subsequent climate change emission reductions.

These policy mechanisms may include regulatory incentives to encourage utilities to promote customer and utility-owned CHP, utility rate structures that are transparent and connected to market forces where externalities such as environmental impacts and transmission and distribution constraints are internalized, rules and regulations enabling easier access to wholesale markets, production tax credits for CHP, and other measures or incentives directed at key commercial and industrial activities in California.

Through existing efficiency commercialization programs at the CEC where relationships have been well established with the commercial and industrial sectors, a set of implementation activities will be developed that include:

Utility tariffs to enable CHP owners to sell excess on-site electricity generation to the utility at prevailing wholesale prices. Existing analysis suggests this would be very effective in stimulating the near-team (next 5 years) market.

Climate change emission reduction credits to reflect the net reduction of climate change emissions for the CHP systems compared to the avoided electricity and boiler fuel emissions.

Transmission and distribution benefit payments that reflect the local and temporal benefits CHP provides utilities.

Utility regulatory incentives to encourage utilities to promote installation of customer- and utility-owned CHP projects.

Municipal Utility Electricity Sector Carbon Policy

The Energy Commission and the CPUC are collaborating on additional programs to address ways to transition away from carbon-intensive electricity sources. Some publicly owned utilities have historically relied on coal-based generation, and many of these facilities will reach the end of their design life by 2020. The Energy Commission will explore options to encourage municipal utilities to transition away from carbon-intensive generation to low-carbon alternatives, and to reduce purchases of carbon-intensive power. Options include establishing emissions targets or caps, providing incentives for preferred generation options, and setting a greenhouse gas performance standard for new utility resource procurement, including both coal and non-coal resource additions.

In its recently adopted *2005 Integrated Energy Policy Report*, the Energy Commission recommends:

A climate change emission performance standard for utility procurement should be set no higher than emission levels from new combined-cycle natural gas turbines.

The state should specify a climate change emission performance standard and apply it to all utility procurement, including in-state generation and out-of-state purchases, coal, and non-coal resources.

Additional consideration is needed before determining what role greenhouse gas offsets could play in complying with such a standard.

The Energy Commission should work with the CPUC to develop a framework that accounts for the financial risk of reliance on carbon-based generation.

California should have a consistent electricity carbon policy for all electric utilities within the state that applies to both in-state generation and out-of-state power purchases.

Alternative Fuels: non-Petroleum Fuels

This strategy involves increasing the use of non-petroleum fuels in California's transportation sector, as recommended in the Energy Commission's *2003 and 2005 Integrated Energy Policy Reports.* The Governor has also directed the Energy Commission to develop a workable, long-term transportation fuels plan that will result in significant gasoline and diesel use and that will establish realistic and achievable objectives. The Bio-Energy Interagency Working Group, which the Energy Commission is leading, has been asked to recommend options for optimizing the market potential for bio-fuels through a coordinated state level effort.

State policy options can take several forms, including technology performance standards, financial incentives, negotiated agreements, voluntary commitments, emissions-intensity benchmarking for fuel producers or automobile manufacturers, or other mandatory measures, such as fuels or motor vehicle standards or a cap and trade program. Based on our analysis, some alternative fuels have been shown to provide cost-effective greenhouse gas reduction benefits. But they face economic, market, or regulatory barriers that are impeding their use.

To achieve the benefits of this strategy, the following implementation issues would need to be overcome:

The high first cost of alternative-fuel vehicles, when compared to conventional vehicles using internal combustion engines.

The absence of a convenient retail fueling network to dispense alternative fuels to customers.

Other regulatory and market barriers.

Measures to Improve Transportation Energy Efficiency

This strategy builds on current efforts to provide a framework for expanded and new initiatives including incentives, tools and information, that advance clean transportation and reduce climate change emissions.

The effort includes the following:

Incorporating energy efficiency and climate change emissions reduction measures into the policy framework governing land use and transportation, including framework for developing energy element in state transportation and regional planning documents.

Increasing incentives and accelerating technology applications to improve transportation system productivity and move toward cleaner and more efficient vehicles, especially for the public sector fleet.

Enhancing outreach and public participation programs to bring a coordinated message of sustainable transportation and root causes of climate change emissions.

Diversifying transportation energy infrastructure and advancing measures to slow the rate of vehicle miles traveled growth and excessive reliance on petroleum.

Smart Land Use and Intelligent Transportation

Smart land use is an umbrella term for strategies that integrate transportation and land-use decisions. Such strategies generally encourage jobs/housing proximity, promote transit-oriented development, and encourage high-density residential/commercial development along transit corridors. These strategies develop more efficient land-use patterns while accommodating a sufficient housing supply within each jurisdiction to match population increases and workforce needs for the full spectrum of the population.

Intelligent Transportation Systems (ITS) is one application of advanced technology systems that improves operational efficiency of transportation system and movement of people, goods and services. Smart land use development and ITS would minimize the need for major capital improvements and highway construction and can provide a host of benefits including more livable

communities, transportation energy efficiency, lower emissions from mobile sources, and a lower-cost provision of public services (e.g., sewer, water).

Governor Schwarzenegger is finalizing a comprehensive 10-year investment strategy, GoCalifornia, with the intent of developing ways to promote, through state investments, incentives and technical assistance, land use, and technology strategies that provide for a prosperous economy, social equity, and a quality environment.

Smart land use, demand management, and value pricing are critical elements in this plan for improving mobility and transportation efficiency. Specific strategies include: ensuring jobs/housing proximity; promoting transit-oriented development; encouraging high density residential/commercial development along transit/rail corridor; valuing and congestion pricing; implementing intelligent transportation systems, traveler information/traffic control, incident management; accelerating the development of broadband infrastructure; and comprehensive, integrated, multimodal planning.

Conservation/Tillage Cover Crops

Conservation tillage and cover crops practices are increasingly being used by California farmers for a variety of reasons, including improved soil tilth, improved water use efficiency, reduced tillage requirements, saving labor and fuel, and reduced fertilizer inputs. However, due to the wide diversity of California agriculture, these practices must be demonstrated in a wide variety of cropping systems, soil types, irrigation regimes, and climate conditions.

This diversity also creates difficulty in quantifying both carbon emissions and potential carbon sequestration benefits from implementing conservation tillage and cover crops in the myriad of California cropping systems. This potential needs to be verified through extensive research directly applied to California conditions. Thus, the potential climate change emission reductions for 2010 and 2020 remains to be determined.

Enteric Fermentation

Enteric fermentation is the process of feed digestion by ruminant animals (primarily dairy and beef cattle). This process results in methane emission from the animals. To reduce climate change emissions resulting from enteric fermentation, feed adjustments may be made that improve milk and meat productivity.

New measures would include establishing a research initiative to quantify emission changes from enteric fermentation resulting from changing feed regimens versus productivity impacts. Different animal populations would have differing abilities to manage feed rations. For example, grass-fed beef would have little to no ability to reduce enteric emissions. Dairy operators vary feed rations based on numerous factors. Feed rations are a complex system that not only provide nutrition to the animal, but also provide cost-effective and efficient use of other agricultural by-products including food processing residuals, fruit culls, almond hulls, cotton seed, and even rice straw.

This system would have to be carefully analyzed to determine overall climate change emission effects if the use of these other residuals is altered. This analysis would include both a technical analysis and a cost effectiveness analysis that would be initiated in 2006.

Pricing of food commodities to reflect embodied climate change emissions is not recommended for any action at this time. A "calcium crisis" currently exists in this country, where a significant portion of women and children are calcium deficient. Milk and dairy products are a major source of calcium that should be available to these at-risk populations, especially those of low and moderate income, at affordable prices.

5.4 Emission Baseline Development

The Energy Commission is continuing to develop an emissions baseline to evaluate progress towards meeting greenhouse gas emissions reduction targets. This baseline is comprised of historical annual values for 1990 through 2002 and projections to 2010 and 2020. The baseline includes emissions from electricity imported into California and excludes international bunker fuels.

Historical baseline emissions are taken from the Energy Commission document *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*.33 Generally accepted emissions inventorying methodologies are being used to estimate California emissions as prescribed by the U.S. Environmental Protection Agency and the Intergovernmental Panel on Climate Change.

The methodology uses aggregated, estimated fuel use data for the state of California obtained from the U.S. Department of Energy's Energy Information Administration and from in-state data sources.

Projected baseline greenhouse gas emissions are obtained from forecasted fuel use data used by the Energy Commission to develop the *2005 Integrated Energy Policy Report (IEPR)*.35 Policies and strategies adopted before December 2004

were also included in the IEPR forecasted fuel use demand and are not considered as potential greenhouse gas emissions reduction strategies by this report. Policies and strategies initiated after the December 2004 date are not in the emissions baseline forecast and are considered by this report as candidates for greenhouse gas emissions reduction strategies.

5.5 Economic Assessment

The overall economic impact of implementing the strategies in Table 5-1 and Table 5-2 are being estimated using a computable general equilibrium (CGE) model of the California economy. A CGE model simulates the functioning of a market economy in which different sectors interact with one another (one sector supplies inputs to another, or purchases the outputs of another) and where prices and production adjust in response to changes caused by government policies applied to specific sectors. The CGE simulates these relationships among California producers, California consumers, government, and the rest of the world. Because of the interconnection between sectors, an intervention in one sector has impacts on all others, which are captured by the CGE model analysis.

Preliminary results for the economic analysis will be included in the report to the Governor and Legislature.

6 CAP AND TRADE OPTIONS FOR CALIFORNIA

“Cap and trade” is a market-based program that can be integral to California’s strategy for reducing climate change emissions. The program sets an emissions cap that can be phased down over time. Regulated sources have flexibility to comply with the cap using methods of their own choosing. The ability to trade emissions among sources enables emission reductions to be achieved at the least cost possible.

Because climate change emissions originate from diverse sources and are long-lived gases in the atmosphere, setting an overall emission cap and allowing emission trading is recognized as a particularly effective strategy for reducing emissions from many (but not all) climate change emission sources. This approach is best applied to sources with emissions that can be measured or calculated reliably. Emission sources that are diffuse, difficult to quantify, or small, are not good candidates for inclusion in a cap and trade program.

The European Union (EU) adopted this approach to reduce climate change emissions from four energy-intensive sectors: (1) energy (electric power, oil refineries, and coke ovens); (2) metal ore, iron and steel production; (3) minerals

(cement, lime, glass, and ceramics); and (4) pulp and paper. Initiated in 2005, the EU program is the largest cap and trade program in the world, involving 25 countries and more than 12,000 installations.

In the U.S., the Acid Rain Trading Program and the Northeast NO_x Program/NO_x SIP Call Program have successfully implemented cap and trade programs to limit air emissions.36 The ability to trade emission allowances has been credited with lowering significantly the cost of reducing emissions under these programs.37 Additionally, compliance has been nearly 100 percent, so that emissions have been reduced as scheduled.38

The primary weakness associated with implementing a cap and trade program in California is that it will be vulnerable to emission "leakage." If the state implements the program without other states, there will be an incentive for activities that emit climate change emissions to shift to neighboring states to avoid the emission cap. If this occurs, emissions may decline in the state, only to increase in other states.

A coordinated national approach to capping climate change emissions within an international framework would be the best approach for addressing this leakage problem. In the absence of national action, leakage may be partially mitigated through the design of the program and ongoing efforts to coordinate with other states, such as the Northeast States or other Western states, that are taking action to reduce climate change emissions.

As part of the implementation of a cap and trade program, data should be collected over time to assess the extent to which leakage occurs, and its impacts on businesses and on the effectiveness of the emissions cap.

6.1 Cap and Trade Program Design Options

Realizing the emissions certainty and the cost advantages of a cap and trade program leads to two overarching program design principles:

Broad Coverage is Preferred:

Broad coverage enables the cap and trade program to have a direct impact on a large portion of total climate change emissions.

By covering a broad range of emission sources, the program can capture the least-cost emission reduction opportunities.

Broad coverage enlarges the set of emissions sources with an incentive to innovate to find ways to reduce emissions.

Flexibility is Preferred: Compliance flexibility lowers the cost of reducing climate change emissions.

Sources can meet their obligation under the cap using methods of their own choosing.

Sources can trade emission allowances.

Sources can bank early emission reductions to reduce compliance costs in subsequent time periods.

The desire for broad coverage and flexibility must be tempered by administrative realities and source-specific considerations. For example, sources with emissions that are difficult to measure or calculate reliably may not be suitable for including under the cap. Similarly, sources that derive from numerous small emission points may be administratively burdensome to include.

There is no one best answer for how to design a cap and trade program to reduce climate change emissions. Rather, trade-offs are required to create a program that promotes low-cost emission reductions in a framework that is equitable and administratively feasible.

The cap and trade program design options are described in terms of:

Scope: The scope of the program defines the sectors, sources, or activities that are included under the cap.

Allowance distribution: Emission allowances can be auctioned or given to regulated sources.

Emission offsets: Offsets are verified emission reductions achieved by facilities that do not fall under the cap and trade program. Whether to allow emission offsets must be defined.

Other Program Design Elements: The climate change emissions included; whether to place restrictions on trading of emission allowances; the manner in which allowances can be banked for future use or borrowed against future limits; and the manner in which compliance and enforcement will be performed must be defined.

6.1.A Program Scope

The program scope defines the entities included in the cap and trade program. We examined three representative alternatives for defining the program scope: a sector-based emissions cap; an emissions cap on major stationary source combustion; and a fuels-based carbon cap.

A sector-based emissions cap could cover up to 30 percent of the state's climate change emissions by focusing on five key industries: electric power; oil refining; oil and gas extraction; landfills; and cement production (see Table 6-1). Reaching this level of coverage requires that the electric power sector be defined to capture all the emissions from electricity consumed in the state.

Approximately 10 percent of state climate change emissions come from in-state generation of electricity, and another 10 percent of emissions comes from out-of-state generation of electricity that is consumed in the state. To include the out-of-state emissions in a cap and trade program, the electric sector can be defined as Load Serving Entities (LSE) rather than electric generation facilities.

LSEs are responsible for procuring and delivering electric power to customers. In California there are three investor owned utilities (IOU) that are LSEs: Pacific Gas and Electric; Southern California Edison; and San Diego Gas and Electric. Municipal utilities, irrigation districts, the Department of Water Resources, and private electric service providers are also LSEs.

Under an LSE-based definition, each LSE would be required to hold emission allowances that cover the emissions associated with the power they deliver to their customers. To comply with its emission limit, each LSE would track or calculate the emissions associated with all the electricity it delivered, regardless of whether it was produced in California or out of state.

This LSE approach differs fundamentally from the option of focusing on in-state generators. Under the LSE approach, LSEs hold the emission allowances—not the generators. Each LSE would have the responsibility to obtain power from the set of generators that enables it to comply with its emission cap. LSEs could trade emission allowances: those with extra allowances could sell to those who need additional allowances, given their procurement decisions.

Table 6-1. Cap and Trade Scope Defined by Sectors

Sector	# Entities	Portion of State Climate Change Emissions

Electric Power Sector:		
Generation Based: In-state generators (≥25 MW)	≈313 facilities	≈10%
Load Serving Entity Based: All Load Serving Entities	≈47 LSEs	≈20%[a]
Other Sectors:		
Oil Refining	21 refineries	≈3%
Oil and Gas Extraction	429 facilities	≈3%
Landfills	≈300 landfills	≈2%
Cement Production	11 cement plants	≈1.5%
Others	(various)	<1%
Mobile Sources:		
Motor Gasoline (light duty vehicles, on and off road)	(Not Applicable)	≈28%
Diesel—on road		≈7%
Domestic Aviation		≈6%
Other		<2%
a. Includes emissions from electricity imports.		
Source: Climate change emissions estimates from Bemis, Gerry and Jennifer Allen, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update*, California Energy Commission Staff Paper, Sacramento, California, Report CEC-600-2005-025, June 2005.		

This LSE-based approach has several advantages.

The LSE-based approach captures a larger portion of climate change emissions than a generator-based definition of the electric power sector.

The LSE-based approach mitigates the emission leakage problem that arises under an in-state generator-based approach. Under the LSE-based option, in-state and out-of-state generation are treated equally, and the cap applies to total emissions associated with all electricity consumed in the state. Therefore, there is no opportunity to avoid the cap and there is no leakage.

The LSE-based approach motivates emission reduction opportunities that are not motivated by a generator-based system. To comply with its emission cap, an

LSE could promote energy efficiency among its customers as a means of reducing the load itself. LSEs can also procure renewable-based power or shift to fossil-generated power sources with lower emissions. An LSE by its nature has a broader set of opportunities for achieving its emissions cap, as compared with an individual power plant owner/operator.

To implement the LSE-based option, the power sector must track emissions associated with all (or nearly all) power generation through the market to its eventual delivery. Such a tracking system does not currently exist, and developing it presents significant challenges. There are several workable approaches for solving this problem, and the effort is worthwhile to enable an LSE-based approach to be used.

The other industrial sectors with significant climate change emissions are oil refining, oil and gas extraction, landfills, and cement production. These industries have a manageable number of facilities that could be included in a cap and trade program (see Table 6-1).

The mobile source sector, the largest individual source of climate change emissions in California (42 percent), is not easily accommodated in a cap and trade program defined in terms of sectors. Diverse factors affect climate change emissions from mobile sources, including the demand for mobility; the cost, availability, and convenience of travel options, including private vehicles and mass transportation; and the emissions per passenger mile of the transportation mode used, which is driven by the technology employed and the fuel used.

A coordinated set of policies is needed to address the factors that influence mobile source climate change emissions: a sector-based cap is necessarily a partial solution. The main practical sector-based option would be to make vehicle manufacturers the point of regulation.

Based on the emission intensity of each vehicle (emissions per mile) and the expected annual miles driven by each vehicle type, the emissions “embedded” in new vehicle sales could be calculated. The manufacturers could be provided with an emission cap for their total new vehicle sales each year. Manufacturers would comply with their caps by reducing the emission intensity of their vehicles or by shifting the mix of vehicles sold toward those with lower emission intensity.

This vehicle manufacturer cap is similar to recently adopted vehicle climate change emission standards that limit average emissions per mile. The standards do not cap total emissions—emissions can increase or decrease as new vehicle sales increase or decrease. By putting a cap on total emissions, the

manufacturer-based emission cap would constrain emissions even if new vehicle sales increase.

While the two regulatory policies do not necessarily conflict, it would be critical to coordinate the two policies if they were to be enacted simultaneously. However, such a cap is probably not needed in the short term, while the emission standards come into force for the first time. Emissions associated with the mobile sector could be monitored over time to assess whether a cap is needed.

An alternative to a sector-based program is an emissions cap on major stationary source combustion in the state. This approach would encompass all major stationary sources of carbon dioxide (CO_2) emissions, without reference to specific sectors as being either in or out of the cap. This scope would not capture mobile source emissions.

Based on preliminary analyses, CO_2 emissions from these sources appear to be concentrated in about 750 facilities statewide. These facilities account for more than 90 percent of CO_2 emissions from stationary fossil fuel combustion, or nearly 20 percent of total state climate change emissions. As discussed above, it may be preferred to define the electric power sector as LSEs to capture emissions associated with imported power and to address the potential for leakage.

The resulting program would be a hybrid approach: the electric sector would be defined to include all LSEs, and all remaining major stationary combustion sources (not including in-state generation) would be included under the stationary source definition.

A third approach to defining the scope of the program is to set a fuels-based carbon cap. This comprehensive fuels approach would reduce climate change emissions by placing a cap on the total carbon content of oil, gas, and coal consumed in the state. The primary advantage of this approach is that it encompasses all sectors that use fossil fuels. Consequently, all options for reducing fossil fuel combustion across all sectors can contribute to achieving the emissions cap.

To achieve climate change emission reductions via this cap, “carbon allowances” would be required to be held by entities at specific points in the distribution or use of fossil fuels in the state. The points at which allowances are required should be selected to minimize administrative burden and maximize coverage and effectiveness. For fuel markets, these considerations favor an “upstream” approach to regulating the total carbon content of fossil fuel combustion: fuel

producers and importers would be required to hold carbon allowances for the fuels they produce in the state or import into the state.[39]

For liquid fuels, carbon allowances could be required where liquid fuels enter into commerce at refineries, marine terminals, and storage facilities. An alternative is to track the carbon content of the crude oil and natural gas liquid inputs to refineries. This refinery input tracking may be simpler than tracking the carbon content of multiple products. Additionally, it has the advantage of incorporating in the cap the carbon emissions from refinery operations. The carbon content of imported refined products would need to be tracked under either option.

The upstream point for tracking natural gas flows would be at major pipeline transfer points and the natural gas utilities. Coal does not appear to have a convenient upstream point in the market for tracking carbon consumption. Because relatively small amounts of coal are used in the state, it may be easiest to track coal combustion downstream; for example, in major boilers.

The comprehensive fuel carbon cap covers about 75 percent of the state climate change emission inventory, including mobile sources. Limits on fossil fuel supply provide incentives for both: (1) improving the efficiency with which fossil fuels are used; and (2) developing non-fossil energy sources. Comprehensive mobile sector improvements are motivated, including shifting modes of transportation, improving vehicle efficiency, and adopting non-fossil based fuels.

This comprehensive fuel approach has several drawbacks. Non-fuel related emissions are, by definition, excluded from the scope of the program. To cover these emissions, a separate program component would be needed for the specific non-fuel related sources and processes. Alternatively, emission reductions from these sources could motivated by making them eligible to produce and sell emission offsets.

Perhaps most significantly, the comprehensive cap on fossil fuel carbon essentially creates an absolute limit on the availability of fossil fuels in the state. The supply constraint would lead to increases in the prices for fuels, which would be the primary motivation for improving fuel use efficiency and for developing alternative fuels. The size of the price increase will depend on the level of the carbon cap and the cost and availability of alternative fuels. During a transition period, prior to the widespread availability of alternative fuels, price increases could be substantial if the fossil fuel carbon cap is set too low.

The impacts of increased fuel prices would need to be mitigated in order to make this approach viable. If the impacts of increased fuel prices could be managed,

California businesses could realize a competitive advantage through access to a more diverse fuel supply that is both less susceptible to price shocks and supply disruptions and more sustainable economically and environmentally. The key to realizing this outcome is to adopt a gradual phase-down of fossil-carbon based fuels that allows improved efficiency and alternative fuels to constrain the rate of price increases.

One way to prevent unacceptably high fuel price increases is to put a maximum value on the carbon allowances, and to make additional carbon allowances available at that maximum value. This "safety valve" for the market sets an upper bound on the impact of the carbon cap on fuel prices. However, it also effectively removes the cap when the maximum value is reached. Nevertheless, a safety valve of this type may be needed to help ensure that unacceptable price increases are avoided during transition periods.

The implementation of this comprehensive fuel approach would need to address the vulnerability of the electricity sector to leakage: the cap on fossil-carbon based fuels would not cover electricity imports. This electric-sector leakage could be addressed by adopting the LSE-based approach discussed above.

The resulting program would be a hybrid: an emissions cap would be placed on the electric sector, defined to include all LSEs, and a cap on fossil-carbon based fuels would also be in place (any fuels used to produce electricity delivered by the LSEs would not count against the fuel cap). The two caps, one on LSE emissions and one on carbon in fuels, could be traded to allow emissions to flow to their most highly valued uses.

If California is the only state in the western U.S. to implement this comprehensive fuel approach, a "black market" for fuels may develop, particularly for liquid transportation fuels. Although marine terminals, storage facilities, and refineries could be tracked, gasoline is easily transported long distances in tanker trucks. Fuel from neighboring states could be trucked into California without the proper carbon allowances. Policing this activity could be difficult, and if significant fuel volumes move through a black market, the effectiveness of the cap will be eroded.

We can make several observations regarding the three representative approaches for defining the scope of a cap and trade program for reducing climate change emissions in California:

The fuel-based carbon cap is the most comprehensive, encompassing the greatest diversity of emission reduction opportunities and motivating action across the broadest set of emission sources (see Figure 6-1).

The sector-based approach focuses attention on the specific industries that contribute most to state climate change emissions. Stationary sources in the largest sectors cover about 30 percent of the state emission inventory. To significantly increase coverage beyond 30 percent, mobile sources, with about 42 percent of the emission inventory, would need to be included in the cap. However, mobile sources are not conducive to a sector-based approach.

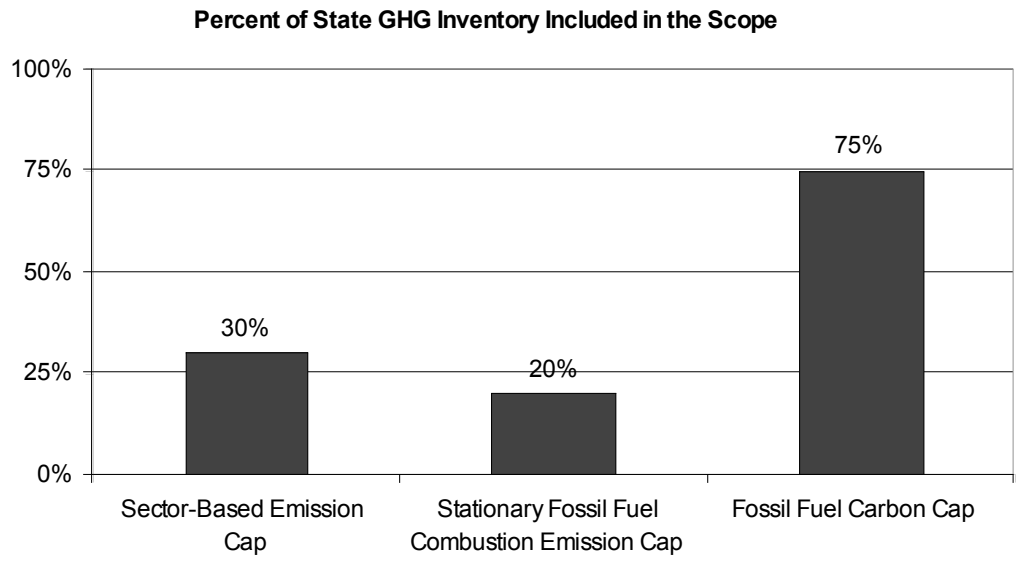
The stationary source definition of program scope encompasses all major stationary sources of CO_2 emissions from fossil fuel combustion, without reference to specific sectors as being either in or out of the cap. Approximately 750 facilities could be included in the program to cover the overwhelming majority of emissions from these sources. This scope does not capture mobile source emissions, and consequently is limited to about 15 to 20 percent of the state inventory. An additional 10 percent of emissions can be covered if emissions associated with imported electricity are captured using a hybrid approach that includes a comprehensive definition of the electricity sector.

All three methods for defining the scope of a cap and trade program are vulnerable to emissions leakage. A coordinated national approach to capping climate change emissions within an international framework would be the best approach for addressing this leakage problem. In the absence of national action, or even regional action, the leakage issues can be partially mitigated.

All three methods appear to be administratively workable. Also, it may be preferred to cap emissions from the electric power sector under all three scope definitions using the LSE-based approach.

All three approaches to defining the program scope could be leveraged into a regional or national climate change emission reduction program. An assessment of the relative likelihood of any of the three approaches being adopted nationally is beyond the scope of this assessment. However, it can be observed that the sector and stationary source approaches are more similar to past national and regional regulatory regional programs than the comprehensive fuel approach.

Figure 6-1: Climate Change Emissions Covered Under Three Definitions for Program Scope



Sector-Based Emission Cap for five sectors, not including mobile sources. See text.

Stationary Fossil Fuel Combustion Emission Cap covering approximately the 750 largest sources. See Text.

6.1.B Allowance Distribution

A cap and trade program requires that each facility under the cap hold sufficient emission allowances to cover its emissions. Emission allowances can be auctioned (i.e., sold) or given away. If given away, the allocation algorithm can have a significant impact on the amount of allowances received by each facility. A hybrid approach can also be used, in which some allowances are given away and some are auctioned.

Much has been written regarding the pros and cons of giving allowances away versus auctioning them.[40] When allowances are given to entities covered by the cap, those entities receive something of value: the emission allowances. When the allowances are auctioned, the government collects a portion of the value of the allowances in the amounts paid in the auction. Both approaches can result in essentially the same cost of controlling emissions, and both approaches are expected to have the same impact on consumer prices in most cases.

If an auction is not used, the process for distributing the allowances typically considers facility-specific factors to promote equity among the regulated facilities. Although various factors can be considered, two primary factors are commonly discussed as bases for distributing emission allowances:

Baseline Emissions. Emission allowances can be distributed on the basis of recent emissions as defined in a baseline for each facility. This method has the potential to distribute fewer allowances to those entities that reduced their emissions prior to the baseline period, thereby penalizing them for taking early action.

Baseline Output. Emission allowances can be distributed using an average emission intensity for each industry and baselines of recent facility output. The average emission intensity for an industry would be equal to the total emission cap for the industry divided by the total baseline industry output. Each facility's allocation would be the product of the relevant industry average emission intensity and the individual facility's baseline output. By using this approach, past actions by a facility that reduced its emission intensity are rewarded.

Insofar as emission allowances are distributed on the basis of past emissions or output, new sources would not receive a share of the distribution of allowances. To address this issue, a portion of the emission cap can be set aside for new sources, so that they can be allocated a share of the cap. Alternatively, a share of the cap could be set aside to be auctioned off, so that all sources, new and existing, could bid for additional emission allowances over and above the allowances they receive through a distribution.

Facilities that have relatively high emissions will favor distributing allowances on the basis of recent emissions, because under this approach they will receive more allowances. Facilities that have relatively low emission intensities will favor distributing allowances on the basis of an industry-average emission intensity. Facilities with growing levels of emissions or output would want to ensure that the method allows flexibility in the selection of the baseline year, so that recent periods of high emissions or output could be considered.

The specification of a distribution algorithm requires balancing divergent interests. One way to satisfy competing interests in this situation is to be overly-generous in the initial allocation of emission allowances. In doing so, all parties can receive a share of the emission cap that meets their current needs. In this case, care must be taken to reduce the cap over time, and to ensure that the extra allowances are not banked indefinitely in a manner that reduces the effectiveness of the emission cap over the long term.

6.1.C Emission Offsets

Emission offsets are verified emission reductions achieved by entities that are outside the cap and trade program. The benefits of emission offsets are:

Offsets help lower the cost of reducing emissions: facilities covered by the cap can purchase low-cost emission reductions from outside the cap as a means of complying with their emission limit.

Offsets provide sources outside the cap with a financial incentive to develop low-cost emission reduction projects, thereby broadening the set of emission reduction opportunities that are motivated to be undertaken by the cap and trade program.

Although the forestry sector is not a strong candidate to include under an emission cap due to the diffuse nature of its emissions (and sinks), stakeholders and others have emphasized that forest management projects in California could be an important source of emission offsets. The funds received from selling the offsets could make forest management projects financially attractive. Of note is that the projects would generate multiple benefits beyond the sequestration of carbon.

To ensure that offsets do not compromise the emission reduction goal of the program, they must be real or additional, quantifiable, surplus to any regulatory requirement, enforceable, and permanent. Also, they cannot be counted toward any other climate change emission reduction targets.

Protocols for verifying offsets will be required for each of a variety of “prototype” emission reduction projects that are deemed eligible for producing emissions offsets under the state’s cap and trade program. Each protocol would address the requirements specific to its prototype project. The California Climate Action Registry’s Forest Project Protocol is an example of the type of protocol that would be needed.

A final issue to address regarding offsets is whether the cap and trade program should rely solely on the market to generate emission offsets, or whether an entity dedicated to producing offsets should be created. A dedicated organization could develop expertise and procedures that enable it to identify and execute emission reduction projects efficiently. The organization could specialize in projects that are particularly relevant to California and qualify under the California program. Following initial funding for start-up, the organization could have the goal of becoming financially self-sustaining.

The primary benefit of creating an organization dedicated to creating offsets is that it can expand the availability of low-cost emission reductions. Initial experience under the primary international offset program (the Clean Development Mechanism) indicates that offset projects may be slow to materialize. The Climate Trust is an example of an organization that was formed to create emission offsets.

6.1.D Other Program Design Elements

To define a cap and trade program fully, the following additional program design elements must be addressed.

Climate Change Emissions Included: To capture as many emission reduction opportunities as possible under the cap, all climate change emissions should be included. However, consideration should be given to limiting coverage, particularly during initial implementation, to those gases and sources that can be measured or calculated reliably.

Trading: Emission trading is fundamental to the cap and trade program as a market-based strategy. However, unlimited trading may raise concerns about the potential concentration of emissions in impacted communities. Trading restrictions could be used to address this issue. However, they are not recommended because the emissions of concern to impacted communities, criteria pollutants and toxics, are better addressed through local air emission restrictions. Climate change emissions themselves do not contribute directly to local environmental quality impacts.

Emission Banking and Borrowing: Banking and borrowing are consistent with the use of a market-based program to achieve emission reductions at the lowest possible cost. Banking, in particular, can motivate early action and reduce overall compliance costs.

6.2 Compliance Tracking and Enforcement

Under all formulations of a cap and trade program, emissions and compliance must be tracked for all the entities covered by the cap, and appropriate action must be taken if entities fail to comply.

Emissions Tracking

Reporting procedures will be required to ensure that facilities produce consistent and reliable emission reports. The California Climate Action Registry has developed and adopted two levels of emission reporting protocols:

A General Reporting Protocol is used by sources that do not have unusual reporting or calculation needs. The GRP can be used by a wide variety of entities.

Industry-specific protocols are used to address data, measurement, calculation, or other issues that are specific to certain industries.

To date the registry has developed protocols specific to the forest sector and the power/utility sector, and work is well along in developing a protocol for the cement production industry. Additional industry-specific protocols will be required if a multi-sector program is adopted, for oil refining, oil and gas extraction, and landfills. The registry's methods produce emission reports that are sufficiently precise to be used by the emissions sources likely to be included in a cap and trade program.

The registry currently requires that emission reports be verified by qualified third-party certifiers, with the cost of certification borne by the reporting entities. With mandatory reporting, we need to assess whether the current process should be continued, or whether a new approach should be used, such as the organization receiving the emission reports being responsible for verifying the emission reports. Both approaches can ensure consistency and maintain quality control of the emission reports. However, centralizing responsibility for verification of the emission reports in the entity that receives the reports may enable efficiencies to be realized.

Compliance Tracking

Compliance is tracked by comparing the emission reports to the official record of emission allowances and emission offsets. A system for tracking the ownership of emission allowances and emission offsets is needed, including "expiring" the allowances and offsets when they are used to cover emissions in a compliance period. The compliance tracking needs to be done in a timely manner, so that compliance can be evaluated shortly after the end of the compliance period.

Enforcement

Enforcement provides consequences in the event that an entity cannot surrender emission allowances in sufficient quantity to cover its actual emissions. The design and implementation of the enforcement requirements will determine the strength of the incentives that entities have to comply. Additionally, the enforcement scheme can have a significant impact on whether the desired emission reductions are achieved.

Options for the consequences of non-compliance include:

Require the entity to acquire emission allowances or offsets to make up its shortfall. Including this requirement will ensure that emissions are reduced to the emission cap.

Require the entity to pay a fee per ton for which they did not have sufficient allowances. Including this requirement provides a financial incentive to comply.

Require that the entity implement controls to reduce emissions. This requirement would reduce compliance flexibility.

If the sole enforcement method is a fee per ton of excess emissions, this would provide a "safety valve" on compliance costs. The fee would become the upper bound for the price of emission allowances. The risk of this approach is that if the fee were set too low, the emission cap may become ineffective, as entities choose to pay the fee rather than reduce emissions.

To ensure that the emission cap remains effective, the non-complying entity may be required to acquire emission allowances or offsets to make up its shortfall. The risk of maintaining the cap in this way is that the cost of the additional allowances may become very high, particularly during a period of non-compliance by many entities.

Significant volatility in the cost of complying can adversely affect the program, and could lead to the cap being relaxed in response to unsustainably high compliance costs. This situation is not hypothetical: the RECLAIM Program in 2000 displayed these conditions.[41]

Specifying the enforcement penalties requires balancing these benefits and risks. Analyses can forecast likely compliance costs and allowance prices. Because there is no track record for a climate change emission cap and trade program in the United States, the forecasts will necessarily be uncertain.

6.3 Conclusions and Next Steps

"Cap and trade" can be integral to California's strategy for reducing climate change emissions. The primary benefits of a cap and trade program are its ability to establish a firm climate change emission limit and to reduce emissions at the least cost.

A cap and trade program can be implemented as part of a comprehensive emission reduction effort that includes complementary programs and initiatives.

A national program to cap climate change emissions within an international framework would be the most effective approach. In the absence of national action, or even regional action, California can lead by example by developing a workable cap and trade program as a model for national action. The added benefit and impact on the state of taking unilateral action must be assessed.

There is no single, best solution for designing an effective cap and trade program. Trade-offs are required to create a program that promotes low-cost emission reductions, in a framework that is equitable and administratively feasible. Divergent interests must be balanced in designing the program scope, emission allowance distribution, and other program elements.

A carbon cap on all fossil fuels provides the broadest single opportunity to reduce emissions, covering about 75% of state climate change emissions, including both stationary and mobile fossil fuel combustion. As an alternative, an emission cap focused on five industrial sectors would cover about 30 percent of state emissions. Mobile source emissions, accounting for about 42 percent of state emissions, are not easily incorporated into a sector-based emission cap. However, alternative strategies can focus on mobile sources.

New legislative authority is required to implement a cap and trade program to reduce climate change emissions.

The CAT finds that a cap and trade program should be considered an integral part of California's approach to reducing climate change emissions. The next steps in considering a cap and trade program include the following:

Facility-level emission reporting is needed, not only to support the detailed design of a cap and trade program, but to better understand current emissions and options for reducing emissions. Consequently, facility-level emission reporting requirements should be adopted, along with the industry-specific reporting protocols needed to support the reporting.

Several complete cap and trade programs should be defined in detail, representing the range of program design options. The program alternatives should be evaluated, including their impacts on climate change emissions; cost of reducing emissions; state competitiveness, business, and jobs; and impacted communities with environmental justice concerns.

Administrative options for implementing a cap and trade program should be developed. The budget requirements to support the administration of the program should be assessed.

The legislative authority required to implement a cap and trade program should be identified.

7 IMPLEMENTATION OPTIONS

This chapter discusses possible implementation options that can be used to reduce climate change emissions in the state as shown in Table 7-1. Some of these options, such as the programmatic and voluntary options, are already being implemented and will continue forward. Others, such as the public good charge for transportation fuels, cut across options and can be used to ensure success. A cap and trade approach is regarded as an attractive means of reducing emissions and was discussed in detail in Section 6. This section discusses fee-based options; however, such an approach would require more extensive examination of the environmental and economic consequences.

In general, the CAT supports the use of multiple implementation options designed to support one another and provide the greatest possible emission reductions for the least cost.

Table 7-1. Implementation Options for Meeting Statewide Climate Change Emission Reduction Targets

Implementation Options
Programmatic
Programs implemented by agencies. Examples of existing programs include ARB's motor vehicle regulations, energy efficiency standards, Renewable Portfolio Standard.
Cap and Trade
Climate change emission cap established for industrial sectors. Trading allowed for flexibility.
Public Goods Charge for Transportation
Transportation is by far the largest source of emissions in the state. A public goods charge on transportation could be used to reduce emissions from transportation sources. Specific emphasis would be placed on transportation fuel diversity that would both benefit the environment and stabilize the economy.
Fee-based Option
Fees could be assessed based on entity emissions, with an emphasis on largest emission sources; or they could be broadly based on energy sources at point of origin or as close to point of origin as possible. Proceeds could be used to provide incentives or otherwise fund emission reduction projects.
Offset Program
Allowing for the purchase of offsets can lower cost. However, it is essential to ensure that offsets are real, quantifiable, surplus, enforceable, and permanent.
Voluntary Emission Reduction Program
Participants work with the state to establish agreed-upon emission reduction activities in support of the Governor's statewide targets.
Mandatory Reporting

Necessity for all programs, tracking, and accountability.

A more detailed description of each of the implementation options in Table 7-1 is included in the subsections below. Mandatory reporting is included in this table because it is key to all of the options considered. Mandatory reporting is also discussed below.

7.1 Programmatic

The programmatic approach has been the mainstay of the agencies represented on the CAT and is reflected in Table 3-1 and Table . State agencies have long been implementing programs that have provided tremendous environmental and economic benefits to the state, including those based on regulations, education, and incentives. Such programs will continue and would be used in combination with other implementation options discussed in this section.

7.2 Cap and Trade

Cap and trade is discussed in detail in Section 6. Further analysis is needed to determine how best to design a cap and trade program for the state. However, a well-designed cap and trade program has the potential to significantly reduce emissions while also providing industry with flexibility and reduced compliance costs.

7.3 Public Goods Charge for Transportation Fuels

Transportation is the largest source of emissions in the state. Accounting for more than 40 percent of the statewide emissions, it dwarfs the next largest sources of emissions—the industrial and electricity sectors—at about 20 percent each. Although both the industrial and electricity sectors are somewhat diversified as to energy source, the same cannot be said of the transportation sector. Petroleum accounts for 99 percent of the fuel used in the transportation sector. The state's dependence on petroleum has been shown to be harmful to public health and the environment.

In further contrast, a relatively benign public goods charge is applied to all other energy sources in the state. Petroleum has been uniquely excluded from this requirement. The public goods charge on electricity has contributed to the fact that Californians use 30 percent less electricity per capita than the average U.S. citizen. Californians benefit from building and appliance energy efficiency programs funded with the public goods charges on electricity and natural gas that provide a net saving of more than $1,000 per household annually.

Demand for petroleum in California and around the world has skyrocketed. Petroleum is a limited resource and much of the supply is located in politically volatile parts of the world. Even so, little has been done to reduce per capita usage that has remained stagnant during the last 30 years. Increases in the price of petroleum have reached new peaks and have been sustained for longer periods of time than in the past.

The economic consequences of the state's dependence on petroleum can be measured in personal, goods and services. and macro-economic terms. Consumers have less disposable income and those with little or no disposable income suffer disproportionately.

The costs of almost all goods and services increase when the cost of petroleum increases and many businesses cannot pass these costs on to consumers. This results in lower profits. In general, small businesses are at greatest risk. Finally, from a macro standpoint, significant petroleum price hikes in 1973–74, 1979–80 and 1990 all led to U.S. recessions. California faces a future of increasing petroleum dependence, supply disruptions and price volatility that will further exacerbate the consequences.

The environmental consequences of petroleum are significant. As indicated above, climate change emissions from the transportation sector are large and growing. Using less petroleum reduces smog-forming and toxic pollutants that occur at each point in the distribution system. Many alternative-fuel vehicles produce fewer emissions than their gasoline counterparts while also contributing to the need for fuel diversity in the transportation sector.

A public goods charge on petroleum would be a very effective, fair, and efficient means to reduce climate change emissions from the transportation sector and mitigate these damaging consequences to our environment and our economy. Such a charge could be used to encourage fuel diversity in the transportation sector and provide funds to create incentives for reductions in climate change emissions from a range of transportation sources. These could include ports, heavy-duty trucks, and off-road transportation sources such as locomotives.

Projects funded would be chosen to provide consumers with direct and indirect economic benefits. If implemented in parity with existing public goods charges on electricity production, it would be equivalent to 2.57 ¢ per gallon of gasoline or diesel at the wholesale level.

7.4 Fee-Based Option

Fee-based options exist and merit further evaluation but have not been fully explored at this point. The primary attractiveness of such programs is that they can be centrally managed and can be targeted towards the largest sources or broadly targeted at energy sources at point of origin or as close to point of origin as possible. Proceeds could be used to provide incentives or otherwise fund emission reduction projects.

At this time the CAT would not recommend this option as it cannot guarantee emission reductions. The extensive consultation with industry and other stakeholders necessary also has not been completed.

7.5 Offset Program

Allowing for the purchase of offsets can lower cost. However, it is essential to ensure that offsets are real, quantifiable, surplus, enforceable, and permanent. A preliminary investigation into offset programs indicates that there are successful examples of such programs.

In Oregon and Washington, the Climate Trust program generates offsets for purchase by industry that take into consideration climate change emission reductions as well as reductions in other pollutants. The focus is to ensure high-quality, cost-effective offsets that provide a permanent and viable nexus between those responsible for climate change emissions and the currently available solutions to reduce and eliminate those emissions over time.

A program similar to the Climate Trust program could be considered for California. Such a program could be designed to address the critical need to reduce pollution in low-income and minority communities and other priority issues in our state. Further analysis and review is needed for this implementation option, so the CAT has no specific recommendation regarding offsets at this juncture.

7.6 Voluntary Actions

There are many proactive industries that are taking actions to reduce climate change emissions. The Sustainable Silicon Valley group is made up of a number of large companies including Calpine, Hewlett-Packard Company, and Pacific Gas and Electric, who have pledged to voluntarily reduce their emissions to 20 percent below 1990 levels by 2010. The California Climate Action Registry allows companies to register their climate change emissions and assists these companies in tracking and reducing these emissions. British Petroleum,

Eastman Kodak, Pacific Forest Trust and U.S. Borax are among the more than 50 companies that are currently members of the registry.

Such voluntary actions are instrumental in the effort to meet statewide targets. The CAT encourages such efforts as evidence that many in the business community as well as with local governments clearly believe action must be taken to reduce climate change emissions.

One of the overarching recommendations, which has been championed by industry and environmental groups alike, is recognition of early actions in any and all emission reduction programs implemented. Recognition of early action is also important as California joins its western state partners and the North East States in cooperative efforts to reduce emissions. State partnerships are expected to lead to national and international cooperative efforts.

7.7 Mandatory Emission Reporting

One of the overarching recommendations included in this report is the need for some level of mandatory reporting that builds upon the California Climate Action Registry. We simply don't have the basic information needed to track and account for emission reductions. The Energy Commission maintains a planning inventory that provides an overall picture of where emissions are coming from in the state. However, this inventory cannot be used for the purposes of determining baseline emissions from a source or for tracking emission reductions from a source.

The California Climate Action Registry does have emissions data that can be used for tracking emissions from a source and for accounting purposes. However, the Registry is voluntary, and many of the largest emitters in the state have not yet joined. There is no way to determine whether or when emission sources will join under the current provisions of law.

A preliminary estimate of the largest sources for which emissions data is needed in the state indicates that it would be prudent to begin with data collection from the electric power sector, oil refining and oil and gas extraction sector, landfills, and cement production. To the extent that industries have joined the registry voluntarily, the CAT believes this fulfills any reporting requirement for climate change emissions data.

As this state moves towards mandatory reporting of climate change emissions, the question as to where that data should be stored and managed arises. The CAT does not believe that such a program can be managed under a non-government organization such as the current Registry. However, some of the

current duties and functions of the Registry could be placed within government for the purposes of mandatory data collection. The registry represents an excellent starting point for the process of mandatory reporting.

The role of Air Quality Management Districts (AQMD), Local Enforcement Agencies (LEA), and other entities with within the state that have permit and enforcement authority will need to be determined. These entities already collect much of the data that would be needed under a mandatory reporting program and have existing enforcement and permit authority. This should be considered as a mandatory reporting program is developed.

8 ECONOMIC ASSESSMENT

An overall economic assessment for the strategies being recommended to the Governor and Legislature is being developed. Beyond the overall economic assessment, the CAT recommends an analysis of the individual strategies to determine the cost effectiveness for each strategy. Further assessment is also needed to evaluate the economic implications of cap and trade program for the state as well as other implementation options.

8.1 Strategy Assessment

A preliminary macroeconomic analysis of the emission reduction strategies is being developed for the report to the Governor and Legislature.

In addition to the macroeconomic assessment, the CAT is recommending that an analysis of the cost effectiveness of the strategies in Table 5-1 be completed. The agency responsible for implementing each strategy will provide the costs associated with implementation and any associated monetary savings or other co-benefits that would be achieved by implementing the strategy.

After assessing the cost effectiveness of each strategy, they will be ranked from lower to higher cost categories by their cost-effectiveness ratio (dollars spent per ton of emissions reduced). In general, the higher the cost-effectiveness ratio, the more expensive the program will be to implement in terms of reducing climate change emissions.

Some strategies may save consumers more money than they cost to implement. Such strategies would be identified as having a negative cost effectiveness ratio. Where co-benefits are associated with a measure that are particularly difficult to quantify, the co-benefit and a qualitative assessment of the range of values that may be attributed to it will be identified. If that potential co-benefit is substantial,

it may serve as a reason for viewing the measure as more cost-effective than the quantitative assessment would indicate.

Thus, to the extent possible, the cost-effectiveness estimates will capture the net social cost per ton of climate change emissions removed. This work would be completed and released at the same time as the updated macroeconomic assessment: the last quarter of 2006.

8.2 Implementation Options Assessment

With the exception of the programmatic option, the implementation options shown in Table 7-1 have not yet been evaluated in terms of their economic impacts.

In the case of the cap and trade implementation option, an economic analysis will be needed once the state determines the design of such a program. By its nature the cap and trade option is designed to reduce the costs associated with achieving emission reductions relative to a command and control approach. Therefore, the primary concern with implementation of this option is typically not the economic impacts but rather the assurance of real emission reductions and the implications for low-income and minority communities.

In the case of the public goods charge for transportation, such a charge would be designed to provide economic security, risk reduction and cost savings to the paying public. In the case of the public goods charge on electricity, California consumers save approximately $1,000 per year as a direct result of conservation efforts.

The public goods charge for transportation would be designed to provide economic benefits as well. Given the current volatility in the price of petroleum, risk reduction for a diversified transportation fuels market and reduced dependence on petroleum will provide a significant benefit to both consumers and to the economy as a whole.

The CAT is not recommending the fee-based and offset program options at this time. Both would require an economic evaluation prior to implementation.

9 IMPACTS ON LOW INCOME AND MINORITY COMMUNITIES

Low-income and minority communities are disproportionately affected by pollution and other adverse environmental damages. Disproportionate access to health care and/or lack or resources have contributed to a situation in which residents of low-income and minority communities are more likely to be exposed

to toxics and other pollutants and are less likely to have the resources to adequately respond. The environmental justice (EJ) movement was created as part of the larger social justice movement with the intent to ensure that residents of low-income and minority communities were equally protected from exposure to toxic and other pollutants.

Environmental justice is an issue that has been embraced as a priority for the Governor and the Legislature. As this state moves forward in reducing climate change emissions, evaluating the impacts of climate change, and considering adaptation strategies, EJ concerns must be addressed.

9.1 Environmental Justice Programs

The Governor's Office of Planning and Research (OPR) is the coordinating agency for environmental justice programs for the state. In 2003, OPR incorporated environmental justice elements within the General Plan Guidelines. This effort marked a beginning to a number of other State agencies, such as California Department of Transportation and the California Resources Agency, in adopting environmental justice policies.

Cal/EPA is the model agency (1999 Statutes) for implementing EJ into its programs, policies, and activities. In 2004, under the Schwarzenegger administration, Cal/EPA established its Intra-agency EJ Strategy, model EJ mission statement, and EJ Action Plan to ensure fair treatment and equity for all Californians regardless of race, age, culture, income, or geographic location.

The EJ Strategy is a long-term planning process and marks an important step toward addressing disproportionate environmental impacts on low-income and minority populations. To compliment the EJ Strategy, Cal/EPA also initiated the EJ Action Plan, a three-year action-oriented process, to explore complex issues such as cumulative impacts and precautionary approaches within six pilot projects throughout various regions in California.

The goal of the action plan is to develop environmental risk reduction plans for children's health, develop guidance for precautionary approaches and cumulative impacts, and improve public participation in the decision-making process. Cal/EPA reports to the Legislature every three years on the status of the EJ Strategy and Action Plan.

9.2 Outreach to Minority and Low Income Communities

In order to solicit comment and promote dialogue with representatives from low-income and minority communities, the Climate Action Team made it a priority to

attend local environmental justice community meetings. At these meetings, CAT representatives provided general background information on climate change and updated the groups on climate change activities and potential issues that might arise. Below is a list of meetings attended:

Date	Organization
September 30, 2005	California Environmental Rights (Los Angeles)
October 5, 2005	North Richmond Air Quality Committee (Richmond)
October 11, 2005	North Richmond Municipal Advisory Committee (Richmond)
December 10, 2005	California Coalition Against Toxics (Los Angeles)

9.3 Strategy Evaluation

As the efforts of the CAT agencies to implement strategies outlined in Table 5-1 move forward, outreach to communities must continue. Each of the agencies on the CAT has committed to support this priority.

Implementation of climate change emission reduction strategies will most likely benefit communities. In many cases, such as electrification of ports, efforts to reduce climate change emissions will provide a direct benefit. In these instances, the support of the communities is essential, and the support of the larger EJ movement will be an asset. If implementation of a strategy would require concomitant measures to ensure against harmful consequences to communities, State agencies must work with communities. In all cases, an open public process that is accessible to community representatives will ensure that EJ concerns are addressed and the statewide targets are met equitably.

9.4 Scenario Analysis

When considering the impacts of climate change on California and adaptation measures necessary, the State must also consider impacts specific to communities and the degree to which low-income and minority residents are affected.

The impacts of global warming will have economic and social consequences for low-income and minority communities. The adaptive capacity of people in these communities is lower than for average Californians.

Specific examples of situations in which low-income and minority communities are likely to be more adversely affected include:

Increasing costs for food, water, and energy will disproportionately affect the low-income communities.

Increasing use of pesticides will have an economic and public health impact on the farm workers.

An increase in the number of days Californians are exposed to ozone will disproportionately affect the people who do not have insurance or access to health care resources.

9.5 Cap and Trade Options

Low-income and minority communities are particularly wary of cap and trade because of the general belief that trading allows for increased emissions at a local level and those increases are believed more likely to occur in the communities. The principal concern is not with the climate change emissions themselves because, in most instances, these emissions do not directly cause local air quality problems. Rather, the concern is with the emissions of other pollutants (CO, NO_x, SO_x, PM, toxics) which may be affected by efforts to reduce climate change emissions. Two types of impacts may be of particular concern:

- Options that reduce climate change emissions could increase emissions of pollutants that cause local air pollution. For example, shifting from a fossil fuel to a biomass fuel could increase emissions of smog-forming pollutants unless appropriate emission control technologies are installed as part of the switch.
- Efforts to reduce climate change emissions may result in facilities with lower climate change emissions per unit of output being operated more than would otherwise be the case. Under these conditions, emissions of local air pollutants may increase near the facility that increases its operations.

In both of these cases, a local community could be impacted by increased emissions, even though climate change emissions decline overall. Because a cap and trade program provides substantial flexibility for facilities to select their preferred methods for achieving the climate change emission cap, the design of the program does not automatically mitigate this concern. Rather, steps must be taken to address this issue through additional measures.

9.6 Implementation Options

For all of the implementation options shown in Table 7-1 it will be essential to involve community representatives as these options are developed. As indicated in Sections 9.5 and 9.6, both the programmatic and cap and trade options will need to involve community representatives.

In the case of the Public Goods Charge for Transportation, the State must work with communities to ensure that costs are not unduly burdensome and benefits are equitable.

Although the CAT is not recommending Fee-Based and Offset Program options at this time, both would require an open public process that ensured participation from communities prior to implementation.

10 SUMMARY AND CLIMATE ACTION TEAM RECOMMENDATIONS

This report lays out a path forward to ensure that California's climate change emission reduction targets are met. Following the signing of Executive Order S-3-05, the Secretary of Cal/EPA created a Climate Action Team. The CAT has accomplished three main objectives: completion of a list of recommended strategies to reduce climate change emissions in the state; completion of a significant first step in what will be an ongoing scenario analysis that provides insight into the impacts of climate change on the state and presents adaptation plans; and evaluation of options for a cap and trade program in the state including next steps recommendations.

The CAT produced three categories of recommendations. First and foremost, the overarching recommendations considered essential by the CAT in meeting the statewide climate change emission reduction targets. The general recommendations listed in Section 10.2 are second tier recommendations that consist primarily of recommended next steps and indications of where further analysis is needed.

10.1 Climate Action Team Overarching Recommendations

The four overarching recommendation of the Climate Action Team that require action by the Governor and the Legislature are identified here. These recommendations are considered essential to meeting the Governor's targets. They are, as a package, intended to encourage investment in technological

solutions to emissions reductions, thereby creating jobs and encouraging economic growth

The Governor and Legislature should direct Cal/EPA, in cooperation with the Climate Action Team, to pursue the necessary steps to implement a mandatory reporting requirement, starting with the largest emission sources. As a basic requirement for tracking and accounting of emissions and emission reductions, it is essential that the State have an implementation inventory that builds upon California's Climate Action Registry and allows this State to track progress towards meeting the Governor's targets.

Currently, the State has a planning inventory that has been developed by the Energy Commission and a voluntary registry, the California Climate Action Registry. Although both are valuable, neither of these provide the essential information needed to track emissions from the largest sources.

The CAT recommends mandatory reporting starting with the largest stationary sources: the electric power sector, oil refining and oil and gas extraction, landfills, and cement production. Once reliable detailed data from these sources of emissions is available, the Governor's targets can be translated into a statewide emission cap for the 2010 and 2020 timeframes (and lay the foundation for a cap and trade program).

The Governor and the Legislature should take steps to implement a public goods charge on petroleum. The revenue generated from this public goods charge would provide funding for key strategies that will reduce climate change emissions and reduce dependence on petroleum. This dependence is harmful to California's economy and also helps foster undesirable geopolitical, energy, and environmental consequences.

Currently, transportation sources are uniquely excluded from public goods charges that apply to all other energy sources in the state. Californians use 30 percent less electricity per capita than the average U.S. citizen; this is partially due to the public goods charge on electricity. Climate change emissions from the electricity sector have decreased over the last 30 years. Californians benefit from building and appliance energy efficiency programs funded with the public goods charges on electricity and natural gas, which provide a net savings of more than $1,000 per household annually.

The same cannot be said of petroleum use within the state: demand has skyrocketed. . The price volatility in the petroleum market has harmed California's economy and is costly to consumers. A public goods charge on

petroleum would be a very effective, fair, and efficient means to mitigate these damaging consequences to our environment and our economy.

As in the other energy sectors, the proceeds would be reinvested to encourage fuel diversity, particularly to encourage the use of biofuels, in the transportation sector and provide incentive funding for reductions in climate change emissions from other transportation sources. These include ports, heavy-duty trucks, and off-road transportation sources such as locomotives. Both economic and environmental benefits to consumers would be considered in the allocation of funds.

The Governor and the Legislature should approve a coordinated investment strategy for State funding programs. The State would modify funding systems, the public pension system, the Public Interest Energy Research fund, and other State investment programs to reflect the commitment and recognition of the many benefits of a low-carbon footprint.

The investment strategy would be designed to provide incentives for industry to develop emission reduction technologies. These technologies could be used in California and exported. They could be used to promote efforts at California universities to explore technological and strategic solutions to reducing emissions.

University efforts to train the technicians of the future would also be encouraged. Not only would this be reflective of the State's commitment to reducing climate change emissions, it would also promote development of climate change emission reduction technologies and support the growth of California businesses.

The Governor and the Legislature should provide early action credit to California businesses. A number of California businesses are supportive of the Governor's targets. These companies have registered emissions and reductions with the California Climate Action Registry. The State should ensure that companies that have been proactive in reducing climate change emissions are not penalized.

As the State develops climate change emission reduction policies, proactive companies must be recognized for their efforts. California businesses have requested the State to take action to support the transition to federal and international emission reduction schemes, including a cap and trade program. The Northeast states are nearing completion of a cap and trade program, and California's companies must be able to participate in joint actions leading to a national and international cooperative effort.

10.2 General Recommendations

General recommendations included in this report are listed below. These recommendations are broken down into broad categories according to their relation to the emission reduction strategies, economics analysis, climate change emission reduction inventory, or cap and trade options.

Economic Analysis

The State needs to take the following actions by November 2006:

Complete an analysis of the individual strategies presented in Table 5-2 to determine the cost-effectiveness for each strategy.

Develop a revised macroeconomic impact assessment to include updated cost estimates for the individual strategies.

Determine updated costs associated with the impacts of climate change on public health, water, agriculture, coastlines, and forests in California.

Determine updated costs associated with adaptation.

Climate Change Emission Inventory

It is essential that the California Energy Commission continue to refine the planning inventory they currently keep.

Cap and Trade

A cap and trade program should be considered further as an integral part of California's approach to reducing climate change emissions. In the absence of national action, California can lead by example by developing a cap and trade program as a model for national action.

Cap and trade program alternatives should be defined in detail and evaluated in terms of impacts on emissions; costs of reducing emissions; state competitiveness, businesses, and jobs; impacted communities with environmental justice concerns; and administrative and budget requirements.

Legislative authority required to implement a cap and trade program should be identified.

Scenario Analysis

California should continue to support research relevant to policy on climate change, including support of the research activities of the California Climate Change Center. Some of the areas of research in need of attention include the

study of ecological impacts, the development of probabilistic climate projections for the state, a geographically-detailed analysis of the impacts of sea level rise on the California coast and the San Francisco Bay and Delta, the impact of climate change on energy generation and demand and human health, and new methods for economic impact analyses.

Climate change may disproportionately impact the most vulnerable groups in our society, including children, the elderly and frail, and residents in low-income and minority communications. For this reason, future scenario analysis should strive to identify these potential impacts and suggest solutions.

Given the serious potential consequences of climate change on the State's resources, California should expand its support of climate change research to create the tools, methods, and information that will be needed to develop robust coping and adaptation strategies in the state.

11 LIST OF ACRONYMS AND ABBREVIATIONS

A1 fi

A2

ARB California Air Resource Board

B1

BEAR

BT&H Business, Transportation and Housing Agency

CA H_2 Net California Hydrogen Highway Network

CalEPA California Environmental Protection Agency

CAT Climate Action Team

CCA Community Choice Aggregators

CDFA Department of Food and Agriculture

CEC California Energy Commission

Center California Climate Change Center

CEQA California Environmental Quality Act

CGE Computable General Equilibrium

CH_4 Methane

CHP Cooling, Heating and Power

CIWMB California Integrated Waste Management Board

CM2.1

CO Carbon Monoxide

CO_2 Carbon Dioxide

CO_2e GHG emmissions expressed as CO_2 equivalent.

DHS Department of Health Services

DOE United States Department o Energy

DWR Department of Water Resources

EAP Energy Action Plan
E-DRAM Environmental Dynamic Revenue Model
EEP
EJ Environmental Justice
EO Executive Order
ESPs Energy Service Providers
EWMP Efficient Water Management Practices
f.sp.pini
GCMs Global Climate Models
GFDL Geophysical Fluid Dynamic Laboratory
GHGs Greenhouse Gases
GWP Global Warming Potential
HadCM3 Hadley Centre Climate Model, version 3
HFC Hydrofluorocarbons
IEPR Integrated Energy Policy Reports
IOU Investor Owned Utility
IPCC Integovernmental Panel on Climate Change
ITS Intelligent Transportation Systems
IWMA
kWh kilowatt hour = 3.6 MJ = 3,412 Btu
LEAs Local Enforcement Agencies
MAF Million Acre Feet
Metz
MMt Million Metric Tons
MOU Memorandum of Understanding
MW
N_2O Nitrous Oxide

NACIP

NAST National Assessment Synthesis Team

NCAR National Center for Atmospheric Research

NMVOCs Nonmethane Volatile Organic Compounds

NO Nitrogen Oxides

NOAA National Oceanic & Atmospheric Administration

NPV Net Present Value

O_3 Tropospheric

ºC Celsius

ODS Ozone Depleting Substances

ºF Farenhieght

PCM1 Parallel Climate Model

PFC Perfluorocarbons

PGC

PIER Public Interest Energy Research

PM Particulate Matter

PPM Parts per Million

PUC Public Utilities Commission

Registry California Climate Action Registrly

RPS Renewable Portfolio Standard

SF_6 Sulfur Hexafluoride

SO_2 Sulfur Dioxide

SRES Special Report on Emissions Scenarios

TRUs Transportation Refrigeration Units

U.S. EPA United States Environmental Protection Agency

UK United Kingdom

VMT Vehicle Miles Traveled

VOC Volatile Organic Compound
W/m_2 Watts per Square Meter
WUI Wildland-Urban Interface

12 ENDNOTES

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22 More discussion on the role of mitigation and adaptation can be found in A. Luers and S. Moser, “Preparing for the Impacts of Climate Change in California: Advancing the Debate on Adaptation,” in review.
23 California Tourism’s Contribution to the California Economy: 1998–2002, <http://www.gocalif.gov/state/tourism/tour_html>
24 G. Franco and A. Sanstad, in review.
25 John Battles et al. in review.
26 Battles et al. in review.
27 Anthony Westerling and Bryant, in review.

28 Tingju, Zhu, Ph.D., “Climate Change and Water Resource Management: Adaptations for Flood Control and Water Supply,” Department of Civil and Environmental Engineering, University of California, Davis.
29 California Environmental Protection Agency Air Resources Board (ARB), Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles, August 6, 2004.
<http://www.arb.ca.gov/regact/grnhsgas/isor.pdf>
30 Adoption of the Proposed Airborne Toxic Control Measure to Limit Diesel-Fueled Commercial Motor Vehicle Idling, ARB, July 22, 2004.
<http://www.arb.ca.gov/regact/idling/idling.htm>
31 This figure is net of added electricity use at truck stops.
32 Report on U.S. Methane Emissions 1990-2020: Inventories, Projections, and Opportunities for Reductions, U.S. EPA, 2001 (EPA 430-R-99-013).
33 Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2002 Update, California Energy Commission, 2005, Publication CEC-600-2005-025, <http://www.energy.ca.gov/2005publications/CEC-600-2005-025/CEC-600-2005-025.PDF>
35 California Energy Commission, California Energy Demand 2006–2016, Staff Energy Demand Forecast; Revised September 2005, Publication CEC-400-2005-034-SF-ED2, September 2005.

<http://www.energy.ca.gov/2005publications/CEC-400-2005-034/CEC-400-2005-034-SF.PDF>

36 The Acid Rain Trading Program caps total sulfur dioxide (SO2) emissions from all fossil-fueled electric generating units in the United States with capacity of 25 MW or more. The Northeast NOx Program caps total emissions of nitrogen oxides (NOx) from electric generating units and large industrial boilers in 19 states and the District of Columbia.

37 Ellerman, A., Paul Joskow Denny, and David Harrison, Emission Trading in the U.S. Experience, Lessons, and Considerations for Greenhouse Gases, Pew Center on Global Climate Change, Washington, D.C., May 2003, pp.12–20 and pp. 29–31. U.S.EPA, Evaluating Ozone Control Programs in the Eastern United States: Focus on the NOx Budget Trading Program, 2004, U.S. EPA, Washington, D.C., EPA454-K-05-001, August 2005, pp. 27-30.

38 A third cap and trade program in the U.S. is the Regional Clean Air Incentives Market (RECLAIM) program. The RECLAIM Program caps NOx and SOx emissions in the South Coast air basin from about 350 NOx sources and 40 SOx sources. In 2000, after seven years of operation, the emission trading market for the RECLAIM Program experienced volatile price swings that eventually led to the program being restructured to exclude electric generating units. Multiple factors contributed to the difficulties in the RECLAIM Program, including impacts from the deregulation of the electric power sector. U.S.EPA, An Evaluation of the South Coast Air Quality Management District's Regional Clean Air Incentive

market—Lessons in Environmental Markets and Innovation, U.S. Environmental Protection Agency, Washington, D.C., 2002, p. 24.

39 An upstream approach to carbon emission trading is discussed in Tim Hargrave, "U.S. Carbon Emissions Trading: Description of an Upstream Approach," Center for Clean Air Policy, Washington, D.C., 1998.

40 See "Who Gains and Who Pays Under Carbon-Allowance Trading? The Distributional Effects of Alternative Policy Designs," Congressional Budget Office, The Congress of the United States, Washington, D.C., 2000.

41 ''An Evaluation of the South Coast Air Quality Management District's Regional Clean Air Incentive market—Lessons in Environmental Markets and Innovation,'' U.S. Environmental Protection Agency, Washington, D.C., 2002, pp. 15-16.